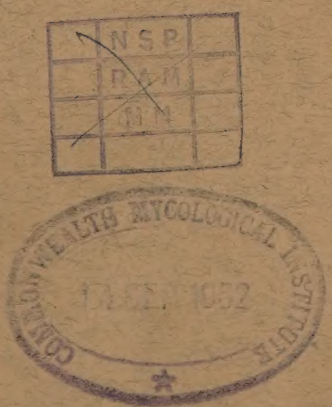
CENTRAL RICE RESEARCH INSTITUTE, CUTTACK

ANNUAL REPORT FOR THE YEAR 1956-57



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Annual Report for the Year 1956-57

Season and Crop Conditions :

The monsoon set in quite early this year and there was a total precipitation of 2,071 mm. (81·56″) as against the normal of 1,557 mm. (61·30″). The rainfall was far in excess of the normal in all months, except in July and the abnormally heavy precipitation in October appeared to have adversely affected the yield of some of the varieties. The distribution of rainfall as compared to the mean of the decade (1946-1956) is given in Table I.

Table I

Rainfall in mm. in 1956-1957 as compared to the average of ten years

Monsoon	Month	Normal rainfall in mm. (Average of ten years)		Rainfall in mm. 1956-57		Deviation from the mean	
S. W. Monsoon	June	200·9	(7·91)	314·2	(12·37)	113·3	(4·46)
	July	274·1	(10·79)	245·4	(9·66)	—28·7	(—1·13)
	August	358·9	(14·13)	560·3	(22·06)	201·4	(7·93)
	September	287·3	(11·31)	407·2	(16·03)	119·9	(4·72)
	Total	1121·2	(44.14)	1527·3	(60·12)	405·9	(15·98)
Post-Monsoon	October	216·4	(8·52)	459·7	(18·10)	243·3	(9·58)
	November	72·6	(2·86)	23·6	(0·93)	—49·0	(—1·93)
	Total	289·0	(11·38)	483·3	(19·03)	194·3	(7·65)
Winter	December	10·9	(0·43)	0·0	(0·00)	—10·9	(—0·43)
	January	7·4	(0·29)	7·6	(0·30)	0·2	(0·01)
	February	20·8	(0·82)	17·5	(0·69)	—3·3	(—0·13)
	Total	39·1	(1·54)	25·1	(0·99)	—14·0	(—0·55)
Pre-Monsoon	March	20·6	(0·81)	26·7	(1·05)	6·1	(0·24)
	April	23·6	(0·93)	6·3	(0·25)	—17·3	(—0·68)
	May	63·5	(2·50)	3·0	(0·12)	—60·5	(—2·38)
	Total	107·7	(4·24)	36·0	(1·42)	—71·7	(—2·82)
	Total for the year	1557·0	(61·30)	2071·5	(81·56)	514·5	(20·26)

N.B.—Figures in brackets indicate the rainfall in inches.

There was no severe attack of pests and diseases but as a prophylactic measure, the crops were sprayed with fungicides and insecticides.

AGRONOMY

I. *Varietal Trials :*

The yield performance of 127 varieties, grouped according to their durations, was tested in five varietal trials in the main season and that of 49 short duration varieties in the second season. Besides, 170 types were also grown in observation plots in the second crop season to determine their suitability for that season.

In the 90-110 days trial, the varieties T. 6522, Ch. 45, AC. 1368, Ch. 63 and Ch. 62 gave higher yields than the control *Benibhog* which yielded 2,443 lb. of grain per acre but the differences were not found to be statistically significant. Of the above varieties T. 6522 is a blast resistant hybrid culture from Madras, and Ch. 45, is resistant to *Helminthosporium* disease.

In the 110-125 days duration trial with 27 varieties, Ch. 55, T. 1839, Ch. 4, Ch. 59, H. 755, BJ. 1, T. 1530 and AC. 1977 gave significantly higher yield than the control T. 635, which yielded 1,040 lb. of gain only per acre. Last year also, the performance of Ch. 4 and Ch. 59 was better than the control ; Ch. 55, H. 755 and BJ. 1 are varieties selected as resistant to blast by the Mycologist.

In the 125-140 days duration trial, 32 varieties were tried against the standard Slo. 6. Varieties T. 874-1-9-2, T. 1879, T. 141-84, SC. 1177-36, T. 588, T. 672, T. 1233, BHF. 345, BHFK. 439, BHF. 535, T. 141-89, BK. 6 and T. 1850 gave significantly higher yield than the control which yielded 1,781 lb. of grain per acre. Last year also, all the above varieties except BHF. 345, BHFK. 439 and BHF. 535, which were included for the first time during this year, were found to be superior to Slo. 6. Selections T. 141-84 and T. 141-89, from a local popular variety T. 141 yielded 13·3 and 6·5 per cent higher yield respectively, than the parent variety. T. 141-89 has consistently been giving higher yield than the parent T. 141 since 1954-55.

In the 150-160 days duration trial, 30 varieties were tried against the standard T. 1242 ; four varieties, *viz.*, BAM. 9, AC. 2732, HR. 35, and J. 192 gave significantly higher yield than the control which yielded 1,630 lb. of grain only per acre. The first three varieties have been consistently giving higher yield than the control for the last three years.

In the trial of varieties of over 170 days duration, 18 varieties were included with T. 1242 as standard. Co. 19 and Ptb. 4 gave significantly higher yield than the control which yielded 2,261 lb. of grain per acre. Co. 19 has consistently given higher yield than T. 1242 during the last five years.

Fortynine promising early varieties were tried for their suitability for the second crop season in a replicated varietal trial. The variety Ptb. 10 was used as the standard. Mtu. 15 and Mtu. 9 produced 99·5 and 91·8 per cent higher yield respectively, than the control, which yielded 1,175 lb. of grain per acre. T. 6517, Co. 10, T. 6522, CB. II, TKM. 6, Teppa I and Ch. 55 were also better than the control. Last year also, Mtu. 15 and Mtu. 9 were found to be the highest yielding varieties in the second season. Of these varieties, T. 6517, T. 6522 and Ch. 55 are blast resistant types.

The introductions from Japan, which are said to be high yielding in that country, do not fare well under conditions obtaining in the main rice season, July-December in India. However, the performance of four Japanese varieties,

viz., Norin 8, Norin 17, Norin 18 and Zuihio were tested this year in the second crop season (December-April) against Ptb. 10 and Mtu. 15 as standards. The experiment was conducted under high fertility conditions (80 lb. N + 40 lb. P_2O_5 per acre). Norin 17 gave a yield of 3,295 lb. per acre and was significantly superior to the yield of the two *indica* standards, Mtu. 15 and Ptb. 10, which gave 2,772 lb. and 1,765 lb. per acre respectively. The other three Japanese varieties, Norin 18, Norin 8 and Zuihio gave 2,536, 2,499, and 2,488 lb. per acre and these were significantly higher than the yield of Ptb. 10.

II. *Manurial Trials :*

1. *Efficiency of nitrogenous fertilizers for rice.*—The experiment was conducted as in the last three years to test the relative efficiency of eight forms of nitorgenous fertilizers. The fertilizers were applied at two levels—20 lb. and 40 lb. N per acre at the time of transplanting. The yields obtained with various fertilizers are given in Table II below :

TABLE II

Yield of grain in lb. per acre

Variety T. 141

Serial No.	Fertilizer	Levels of N		Mean
		20 lb. N/A	40 lb. N/A	
1	Ammonium sulphate	3,318	3,517	3,418
2	Ammonium chloride	3,215	3,415	3,333
3	Ammonium phosphate	2,918	3,481	3,200
4	Urea	3,004	3,331	3,168
5	Ammonium sulphate nitrate	2,935	3,370	3,153
6	Ammonium nitrate	2,713	3,117	2,915
7	Calcium cynamide	2,741	3,079	2,910
8	Sodium nitrate	2,706	2,638	2,672
9	Control	2,572		2,572
	Mean :	2,944	3,248	

1. C. D. (·05) per acre for comparing form means	252
2. C. D. (·05) per acre for comparing level means	126
3. C. D. (·05) per acre for comparing individual means	366

As shown in the table above, ammonium sulphate was the best, giving an increase of 746 and 945 lb. of grain per acre with 20 and 40 lb. N per acre respectively. The increase in yield obtained, however, was found to be statistically on par with those obtained with ammonium chloride, ammonium phosphate and urea ; calcium cynamide and sodium nitrate gave poor response.

2. *Placement and split application of ammonium sulphate.*—This experiment has been in progress since 1952-53 with a view to study the effect of placement of fertilizers in split doses at different stages of plant growth on the crop yield. It was repeated this season for the fourth year in succession with long duration variety T. 1242 under low lying conditions. The results obtained are presented in Table III below :

TABLE III

Yield of grain in lb. per acre

Variety T. 1242

Treatment	Nitrogen level lb. per acre		Mean
	20 lb. N/A	40 lb. N/A	
Time of application—			
1. At planting	1,442	1,613	1,528
2. One month after planting	1,321	1,570	1,446
3. One month before flowering	1,386	1,616	1,501
Method of application—			
1. Surface	1,301	1,509	1,405
2. Sub-surface	1,465	1,689	1,577
Split doses—			
1. One dose	1,383	1,599	1,491
2. Two doses	..	1,761	1,761
3. Three doses	..	1,827	1,827
Controls	1,136		1,136
C. D. (·05) per acre for individual means			209

The results obtained are in conformity with those of previous years. Fractional application of the fertilizer again gave better yields than entire quantity applied in one dose, and the highest response was obtained, as before, with sub-surface application of fertilizer in three doses, *i.e.*, $\frac{1}{2}$ at planting, $\frac{1}{4}$ one month after and $\frac{1}{4}$ one month before flowering to give in all 40 lb. N per acre.

3. *Placement and split application of nitrogenous fertilizer.*—With a view to study the effect of placement and split application of various nitrogenous fertilizers on the yield of the crop, four fertilizers *viz.*, ammonium sulphate, ammonium phosphate, urea and ammonium chloride were tested at 30 lb. N per acre. All the fertilizers gave significantly higher yield than the control. Yield differences between ammonium sulphate, ammonium chloride and

ammonium phosphate were not found to be significant. The respone obtained with urea was equal to that with ammonium phosphate and chloride but was significantly inferior to that with ammonium sulphate. Sub-surface and split application of fertilizers increased the yield of the crop as compared to the surface application. The yield data are given in the Table IV.

TABLE IV

Yield of grain in lb. per acre

Variety BAM.9

Placement and split application of fertilizers	Ammonium sulphate	Ammonium phosphate	Ammonium chloride	Urea	Mean	Percentage over control
1. Surface at planting	1,830	1,786	1,812	1,680	1,777	117·4
2. Sub-surface at planting	1,992	1,884	1,949	1,853	1,920	126·8
3. Sub-surface one month after planting	1,941	1,904	1,947	1,776	1,892	125·2
4. ½ sub-surface at planting and ½ sub-surface one month after	2,146	2,069	2,020	1,968	2,051	135·6
5. ½ sub-surface at planting + ½ sub-surface one month before flowering	2,320	2,229	2,241	2,013	2,201	145·5
Control					1,513	100·0
Mean	2,046	1,974	1,994	1,858		

C. D. (·05) per acre for comparing individual means 275
C. D. (·05) per acre for comparing method means 137
C. D. (·05) per acre for comparing form means 123

The highest yields were obtained with the treatment—½ sub-surface at planting + ½ sub-surface one month before flowering, with all the fertilizers. This experiment was conducted in the second season also and similar results were obtained except that ammonium sulphate was surpassed by ammonium phosphate but the differences were not found to be statistically significant. Therefore, from the data obtained so far from these experiments, it may be concluded that the efficiency of the fertilizer is increased by sub-surface application and by supplying fertilizer at different stages of the plant growth, *i.e.*, ½ at planting and ½ one month before flowering.

4. *Long range manurial experiments.*—As previously reported, these experiments are designed to investigate the cumulative effect of continuous application of various fertilizers and manures on the yield of the crop and the productivity status of rice soil.

Ammonium sulphate with and without lime and compost.—This experiment has been in progress for the last eight years to study whether the continuous application of ammonium sulphate in varying doses has any deleterious effect on productivity of the soil, and if so, whether it can be counteracted by the application of organic matter like compost and a soil ameliorant like lime.

Ammonium sulphate @ 0, 20 and 40 lb. N per acre is being applied year after year on the same land with and without 100 mds. of compost as basal dressing. Lime is applied once in three years @ 0, 4 and 8 cwt. lime per acre. The results are presented in the following Table V(a) and V(b):

TABLE V(a)

Yield of grain in lb. per acre

Variety T. 1145

Lime in Cwt./A	Top dressing of Ammonium sulphate—Nitrogen lb./A								Over all Mean
	No compost				Compost at 100 mds./A				
	N_0	N_{20}	N_{40}	Mean	N_0	N_{20}	N_{40}	Mean	
L_0	1,904	2,531	2,712	2,382	2,668	2,926	2,948	2,847	2,615
L_4	1,882	2,458	2,716	2,352	2,520	2,901	2,931	2,784	2,658
L_8	1,814	2,422	2,797	2,344	2,547	2,909	2,847	2,768	2,556
Mean	1,866	2,470	2,742		2,578	2,912	2,908		

TABLE V(b)

Yield of grain in lb. per acre averaged over lime treatments

Compost	Nitrogen levels			Mean
	N_0	N_{20}	N_{40}	
C_0	1,866	2,470	2,742	2,359
C_1	2,578	2,912	2,908	2,799
Mean	2,222	2,691	2,825	2,579

1. C. D. (·05) per acre to compare compost means	198
2. C. D. (·05) per acre to compare N means	86
3. C. D. (·05) per acre to compare compost means at the same level of N	268
4. C. D. (·05) per acre to compare N means at the same level of compost	120

As seen from the above tables, the yield of the crop increased with the increasing doses of N but the application of lime either alone or in conjunction with ammonium sulphate or compost had no effect upon the yield of the crop.

So far no deleterious effect has been found in the plots to which ammonium sulpnate alone has been applied continuously.

Ammonium sulphate with and without compost :

This experiment was repeated for the 8th year in succession on the same site. In this experiment ammonium sulphate @ 0, 20, 40, 60 and 80 lb. N per acre is being applied year after year on the same land with and without 100 mds. of compost per acre. As in previous years, the effect of ammonium sulphate and compost was significant and also their interaction. Increasing response with the application of fertilizer were obtained upto 60 lb. N per acre beyond which the response declined. Compost when supplemented with 40 lb. Nitrogen per acre gave the highest yield in the experiment and further increase in the levels of N lowerd the yield as is seen from the following Table VI.

TABLE VI

Yield of grain in lb. per acre

Variety T. 1145

Top dressing of ammonium sulphate N in lb./A	Basal dressing of compost in mds. per acre		Mean
	C_0	C_{100}	
N_0	1,743	2,420	2,082
N_{20}	2,151	2,730	2,441
N_{40}	2,487	2,892	2,689
N_{60}	2,608	2,499	2,554
N_{80}	2,503	2,169	2,336
Mean	2,298	2,542	

1. C. D. (·05) per acre for comparing compost means	216
2. C. D. (·05) per acre for comparing N means	159
3. C. D. (·05) per acre for comparing compost means at the same level of N	348
4. C. D. (·05) per acre for comparing N means at the same level of compost	225

The yield—nitrogen relationship can be represented by the quadratic curve as given by the equation :—

No compost $Y=1727{\cdot}08+27{\cdot}57x-0{\cdot}22x^2$

Compost $Y=2426{\cdot}77+22{\cdot}53x-0{\cdot}33x^2$

Where Y is the expected yield in lb. per acre and x the N level. From the Yield—nitrogen quadratic function, the estimated maximum yield of 2,811 and 2,591 lb. per acre was obtained with 34 lb. and 64 lb. N per acre in the form of ammonium sulphate applied over compost and no compost respectively.

N. P. K. Trial :

The experiment now in the 8th year, is designed to find a suitable combination of major plant nutrients N, P and K for rice and to estimate their comparative performance with the basal dressings of organic manures.

Ammonium sulphate @ 0, 40 and 80 lb. Nitrogen per acre, Superphosphate @ 0, 50 and 100 lb. P_2O_5 and Potassium sulphate @ 0, 30 and 60 lb. K_2O per acre were applied alone as well as in their different combinations with and without a basal dressing of 20 lb. N per acre in the form of compost, ground-nut cake and green manure. The results obtained are presented in Table VII(a) and VII(b)

TABLE VII(a)

Yield of grain in lb. per acre

Variety T. 1145

Top dressing of ammonium sulphate in lb./A	Basal dressing of organics at 20 lb. N/A				
	No manure	Green manure	Compost	Groundnut cake	Mean
N_0	1,837	2,318	2,470	2,370	2,249
N_{40}	2,143	2,276	2,381	2,246	2,260
N_{80}	1,843	1,654	1,750	1,688	1,734
Mean	1,941	2,083	2,200	2,101	

TABLE VII(b) (PXK)

Levels of P	Levels of K			
	K_0	K_{30}	K_{60}	Mean
P_0	2,087	1,988	2,103	2,059
P_{50}	2,094	2,109	2,118	2,107
P_{100}	2,105	2,116	2,115	2,112
Mean	2,095	2,071	2,112	

1. C. D. (·05) per acre for comparing organic means 313
2. C. D. (·05) per acre for comparing N means 79
3. C. D. (·05) per acre for comparing N means at the same level of compost 159
4. C. D. (·05) per acre for comparing compost means at the same level of N 341

Application of organic manure at 20 lb. N gave yields comparable to that obtained under 40 lb. N per acre in the form of ammonium sulphate alone. Combination of organics with 40 lb. N/A did not affect the yield but further increase in the levels of N to 80 lb. N depressed the yield. Neither phosphorus nor potash had any effect upon the ultimate yield of the crop. These results are in conformity with those obtained during the last eight years.

III. *Trials with green manure crops :*

Under the Indian Council of Agricultural Research Scheme for the improvement of green manuring crops for rice, 99 green manuring species were collected and after a preliminary screening study in 1955-56, 43 were brought forward for detailed study during the year.

From investigations on the suitability of different species for the main and second crop seasons, it was found that within 6 weeks of growth between May and July more than 5,000 lb. of green matter was produced by Sunnhemp, *Sesbania sericea*, *S. macrocarpa*, *S. speciosa*, Cowpea, and *mung*. During the same priod, nearly 4,000 lb. of green matter was also produced by *Crotalaria usaramoensis*, *Aeschynomene americana*, *Phaseolus semi-erectus*, and *Cassia leschenaultiana*. All these above species, therefore, may be considered suitable as green manures for the main season rice crop.

Similarly between November and January, within a period of 8 weeks, 4,000 lb. of green matter was produced by *Sesbania sericea*, *S. macrocarpa*, *S. speciosa*, *Crotalaria usaramoensis*, Cowpea, *mung*, *dhaincha* and black gram. All the above species may be considered suitable as green manures for the second crop of rice which is generally transplanted in January.

In a third study, 17 green manure species were sown in the month of May and after eight weeks they were burried *in situ* and rice was transplanted immediately. The yield of rice in the control plot was 2,719 lb. and the yield was increased by 11·3 to 13·2 per cent in the plots treated with *dhaincha*, *Sesbania speciosa*, *Phaseolus semi-erectus* and *Aeschynomene americana*.

It was found that there was no significant difference between the yield obtained by rice, treated with 5,000-6,000 lb. of *dhaincha* and Sunnhemp, either grown *in situ* or brought from outside. In this experiment, P_2O_5 at 50 lb. per acre, ammonium sulphate at 30 lb. N per acre and lime at half a ton per acre were also added over the basal dressing of green matter. There was no significant response to any of the treatments when applied alone or in combination. On the other hand, the addition of ammonium sulphate resulted in excessive vegetative growth and lodging of the rice.

The following species were found particularly resistant to drought conditions. *Sesbania macrocarpa*, *S. sericea*, *S. speciosa*, *dhaincha*, Sunnhemp, Black gram and *Aeschynomene americana*. They produced nearly 5,000 lb. of green matter per acre within 8 weeks of growth during March-May, which are very hot and dry months.

The following species were found suitable for growing under water logged conditions. *Sesbania aculeata* (*dhaincha*), *S. sericea*, *S. macrocarpa*, *S. speciosa*, *Aeschynomene americana*, *Phaseolus semi-erectus*, *Cassia tora* and *Cassia usaramoensis*. More than 3,000 lb. of green matter was produced by these within 8 weeks of growth under water logged conditions.

In a preliminary study, *dhaincha* was sown in standing rice crop in April and harvested in August. An yield of 14,000 lb. of green matter was obtained by this method. *Gliricidia maculata*, a perennial shrub planted in roadside was found to give 30-45 lb. of green matter per plant.

As in previous years, it was seen that *Crotalaria usaramoensis* and *Crotalaria brownei* have higher nitorgen content (1·0 to 1·3 per cent on fresh weight basis) which is nearly double that of *Dhaincha*. *Sesbania speciosa*, Sunnhemp, *dhaincha*, and *Cassia tora* have higher percentage of carbon (35-44 per cent) while most of the slow growing varieties like *Phaseolus semi-erectus* and *P. trilobus*, contain low amount of carbon and correspondingly narrow C/N ratio (7·5 to 9·8).

In investigations on the optimum age and time of burying green manure crops to rice it was found that *dhaincha* becomes woody within 8 weeks of growth, while the latter set of species remain succulent even at this stage. Rice crop following 8 weeks old *dhaincha* buried at planting gave 2,235 lb. per acre while similar yield response (2,242 lb. per acre) was obtained with 12 weeks old *dhaincha* only when it was buried 8 weeks before planting of rice crop. The green manure when 8 weeks old was succulent and required very little time for decomposition, while the 12 week old crop was woody and required about 8 weeks for getting completely decomposed.

An experiment was conducted to see whether *mung* crop buried in after seeding and harvest is as efficacious in increasing yield of rice as *mung* crop buried at flowering. It was found that significant increase in the yield of rice was obtained by the latter treatment, the increase being 380 lb. per acre. In the above experiment P_2O_5 (30 lb. per acre) applied to *mung* or rice did not result in any significant increase in yield.

In addition to the trials conducted in this Institute, the promising varieties of green manure crops were supplied to different States for trials under different environmental conditions. The reports from these centres are awaited.

IV. *Cultural Trials*

Crop Sequence Experiment 1.—(with leguminous and other crops).—This experiment has been in progress since 1953-54 to determine the possibility of growing different legumes and cash crops in sequence with main season rice crop, and was repeated this year with twelve rotational treatments in three replications. Eight different crops, besides *dalua* or *boro* crop of rice were grown during the preceeding winter season to determine their suitability for inclusion in the sequence of cropping with rice. The rice crop following winter groundnut, gave significantly higher yield of grain per acre than rice after fallow. Rice following *mung*, *mung* plus *pillipesara* and gram also yielded more than fallow/rice treatment but the differences were not found to be statistically significant. The different crop sequences tried and the yields obtained are presented in Table VIII below :

TABLE VIII

Yield of rice and different single season rotation crops

Serial No.	Rotational Treatment	Yield in lb. per acre	
		Preceeding subsidiary crop	Succeeding rice crop
1.	Fallow/Rice	..	1,942
2.	Rice (Ptb. 10)/Rice	1,284	1,424
3.	Dhaincha for green manuring/Rice (Ptb. 10)/rice	1,467	1,567
4.	Mung for green manuring/Rice (Ptb. 10)/rice	1,308	1,569
5.	Mung for seed (Type No. 1)/Rice	99	1,974
6.	Mung for seed+Pillipesara/rice	70	2,201
7.	Gram (T. 87)/rice	562	2,136
8.	Groundnut (TMV. 2)/rice	2,846	2,274
9.	Cotton (P. 216F)—(Seed-Cotton)/Rice	984	1,942
10.	Wheat (NP. 761)/Rice	750	1,851
11.	Linseed (RR. 40)/rice	518	1,955
12.	Mustard (P-77)/rice	140	2,027
	C. D. (·05) per acre for treatment means	..	291

The results of the experiment are in conformity with those of previous years and show that inclusion of groundnut and other leguminous crops in sequence with rice is very profitable. Double cropping of rice with green manuring given to the rice grown in December-April gave about 3,000 lb. of paddy per acre on the whole.

Crop sequence Experiment 2.—(*Sequence with jute*).—During the last two years three crops of rice in a year were successfully grown on the same land with suitable varieties under irrigated conditions by adjusting the dates of planting. Yields of over 9,000 lb. of paddy per acre were obtained. In order to see whether the introduction of a jute crop in the place of the rice grown during March-July would be feasible and more profitable than raising 3 crops of rice, this experiment was repeated this year with the modification given below in Table IX. The yield obtained with jute and the two crops of rice are given in the Table. The experimental results show that jute crop followed by 2 rice crops can be successfully grown on the same land during the year under irrigated conditions.

TABLE IX

Sowing, harvesting and yield data

	1st crop jute	2nd crop rice	3rd crop rice
Variety	J.R.S. 212	T. 141	Ptb. 10
Date of sowing	17-4-1956	12-8-1956	23-12-1956
Date of planting	..	12-9-1956	5-2-1957
Date of harvesting	5-9-1956	2-1-1957	15-4-1957
Yield per acre in lb.	1221 (fiber)	2180 (paddy)	1896 (paddy)

V. *Herbicides for weed control in rice fields*

This experiment has been in progress for the last four years to evaluate the comparative efficiency of various selective herbicides for control of weeds in rice fields. The treatments included nine different herbicides at 2 lb. acid equivalent in 100 gallons of water, customary hand-weeding and interculturing with Japanese rotary weeder. The herbicides were sprayed once, at six weeks after planting of the crop. Interculturing with Japanese weeder was done thrice at fortnightly intervals and hand-weeding was done twice.

These herbicides were found to be successful in controlling broad-leaved weeds and *Cyperus* spp. very commonly found in rice field, but were not effective against grass weeds. The yield obtained in the different treatments is given in Table X.

TABLE X

Yield of grain in lb. per acre

Variety T. 141

Serial No.	Treatments	Yield of grain in lb. per acre	Percentage over control
1.	Agroxone-3	2,995	138·8
2.	Phenoxylene-30	2,949	136·6
3.	Ishihara 2,4-D	2,761	127·9
4.	Fernoxone	2,687	124·5
5.	Hand-weeding	2,643	122·5
6.	Cornox	2,610	120·9
7.	Chloroxone	2,584	119·7
8.	Japanese weeder	2,571	119·1
9.	Shell 2,4-D	2,453	113·7
10.	Kathon M-7	2,394	110·9
11.	2,4,5-T	2,217	102·7
12.	Control	2,158	100·0
	C. D. (·05) per acre	283	

All the Weedicide treatments except Kathon M-7, and 2,4,5-T, as well as the hand-weeding and Japanese weeder were associated with significant higher yeilds than the control. Of the Weedicides, Agroxone-3, Phenoxylene-30 and Ishihara 2,4-D were significantly superior to all the other treatments as regards yield.

During the last three years the Weedicides of MCPA formulations were consistently superior to 2,4-D formulations as regards yield, but during this year it was found that the yeild obtained by Ishihara 2,4-D, Agroxone-3, Phenoxylene-30 was statistically on par.

Time of spraying of herbicides.—To determine the optimum time of spraying the herbicides, Phenoxylene-30 and Chloroxone were sprayed 2, 6 and 10 weeks after transplanting at the rate of 2 lb. acid equivalent in 100 gallons of water per acre. Hand-weeding and unsprayed control were the other treatments. Spraying the crop 2 and 6 weeks after transplanting resulted in significant increases in yield over the unweeded control but were on par with the yield obtained with hand-weeding. Spraying the crop 10 weeks after transplanting resulted in a slightly lower yield than that of the control. The two chemicals tried, Phenoxylene-30 and Chloroxone were equally effective. The yield data are given in Table XI below :

TABLE XI

Yield of grain in lb. per acre

Variety T. 141

Serial No.	Treatment	Weeks after planting			Mean
		2 weeks	6 weeks	10 weeks	
1.	Chloroxone	2,567	2,602	2,282	2,484
2.	Phenoxylene-30	2,652	2,611	2,261	2,508
3.	Hand-weeding				2,536
4.	Control				2,310
	Mean :	2,610	2,607	2,272	
	C. D. (·05) per acre for comparing treatment means				211

Therefore 2 to 6 weeks after transplanting was the optimum time for spraying herbicides. The results are in conformity with those of the previous years.

Nursery treatment experiment.—In the second crop season, different methods of raising seedlings, *viz.*, wet and dry nursery, manured and unmanured seed-beds, beds covered with Alkathene and uncovered beds, were compared to study their effect upon the final yield of the crop. There was no significant difference between treatments as far as the final yield was concerned. During last year also similar results were obtained.

Optimum time of planting paddy in the second season.—To determine the optimum time of planting in the second crop season, six early varieties were planted at regular intervals of 18 days starting from 5th December, 1956. The first two plantings generally gave uneven stand, unsatisfactory growth and the crop became heavily attacked by diseases resulting in poor yields. The yield of the crop increased significantly with the advancement in the planting dates as is seen from the Table XII given below :

TABLE XII

Yield of grain in lb. per acre

Serial No.	Variety	Date of planting				Mean
		1st planting 5th Dec., 1956	2nd planting 23rd Dec., 1956	3rd planting 11th Jan., 1957	4th planting 29th Jan., 1957	
1.	Ptb. 10	750	1,940	2,493	2,830	2,003
2.	CH. 62	296	1,368	1,917	1,966	1,386
3.	CH. 63	542	1,375	1,784	2,042	1,436
4.	Mtu. 15	2,110	1,663	1,246	1,576	1,649
5.	CB. I	1,364	1,564	1,705	2,352	1,746
6.	Teppa. I	1,470	1,784	2,144	2,500	1,975
	Mean :	1,088	1,616	1,881	2,211	

1. C. D. (·05) per acre for dates of planting means 171 lb.
2. C. D. (·05) per acre for varieties means 167 lb.
3. C. D. (·05) per acre for varieties × dates of planting means 296 lb.

Ptb. 10 and Teppa. I gave, on an average significantly higher yield of grain per acre than the rest of the varieties under trial. CB. I and Mtu. 15 were next in order of merit and were followed by CH. 63 and CH. 62 respectively.

However, Mtu. 15 gave the highest yield in the first planting and there was a progressive decline in yield with the later plantings, while the reverse was the case with all other varieties. Mtu. 15 is a suitable variety for early plantings while the others can be used for later plantings in the month of January.

BOTANY

I. *Maintenance and study of Genetic Stocks :*

During the year, 47 rice varieties were added to the collection of Genetic Stocks, which now consists of 3361 types. These new additions were received from Egypt, Gold Coast, Iran, Philippines, Sierra Leone, U.S.S.R., the F.A.O. Rice Expert at Bangkok and some States in India. In addition to above, 6 wild species (2 from Japan and 4 from Surinam) were also received and are being studied. In response to requests, seed samples of 246 genetic stocks were supplied to 13 countries abroad and to various States in India.

The Director, Central Rice Research Institute, continued to be in charge of the overall supervision of the Scheme of the Food and Agricultural Organization of the United Nations, for the maintenance of World Genetic Stocks at five centres, *viz.*, India, Indonesia, Japan, Pakistan and U. S. A. Seven hundred and twenty-one Genetic Stocks received so far, out of 795 registered with the F.A.O., were raised during the year.

With a view to maintain the purity of the Genetic Stocks, characters noted previously were checked once again, and off types, if any, were removed.

Based on height, ear-bearing tillers, maturity and yield, 72 promising varieties from Genetic Stocks were selected for preliminary yield trials. These included 18 types with stiff straw and non-lodging habit.

II. *Improving yield by :*

A. *Introduction.*—Seventy four types selected from Genetic Stocks last year, were tried in four preliminary yield trials, with the varieties grouped according to their duration ; this included 26 promising types, brought forward from last year's yield trials.

(i) *111-120 days' duration trial.*—In this trial, eight types were tried against two local standards *viz.*, N. 136 and BAM 12. Type AC. 1,424 yielded 2,488 lb. per acre which was 72·6 per cent. significantly higher than the yield of the standard BAM. 12 (1,441 lb. per acre). Two other types, *viz.*, AC. 156 and AC. 503, yielded 1,790 and 1,551 lb. per acre respectively, and these were significantly better than the 2nd standard N. 136(982 lb. per acre), the increase being 72·1 and 58·0 per cent. respectively. Of these three superior types, the first two have red rice, while the third one *viz.*, AC. 503 is white kernelled. All the three superior types are from India.

(ii) *121-130 days' duration trial.*—In this trial, seven types were tested against T. 635 standard. Three types *viz.*, AC. 3293, AC. 1620 and AC. 783 yielded 1374, 1209 and 1171 lb. per acre respectively, which was 19·4, 5·0 and 1·7 per cent. more than the yield of the standard T. 635 (1151 lb. per acre). Three of these seven types, *viz.*, AC. 783, AC. 3293 and AC. 448 were severely attached by gall fly (*Pachydiplosis oryzae*). The crop was sprayed twice with insecticide to control the pest.

(iii) *141-150 days' duration trial.*—In this trial, seventeen types were tried against the Standard T. 141. The types RDR. 4, T. 2097, and W. 140, yielded 2684, 2597 and 2556 lb. per acre respectively, while the standard T. 141, gave 3033 lb. per acre ; however, there was no significant difference between these yields. Two of the varieties *viz.*, RDR. 4, T. 2097 were from previous year's trial. All the varieties except W. 681 and W. 682, lodged.

(vi) *151-160 days' duration trial.*—In this trial, twenty four types were tried against T. 412 and T. 1242 as standards. Due to the severe incidence to insect attack and low-lying nature of the plots, growth of all the varieties was rather poor. Six types, viz., W. 428, AC. 3035, W. 440, AC. 3051, W. 719 and W. 467 yielding 2132, 2014, 1838, 1772, 1728 and 1698 lb. per acre respectively, were significantly better than T. 1242, (the higher yielding of the two standards), which yielded 1301 lb. per acre. During last year two of these types, viz., AC. 3035, and AC. 3051 had yielded 14·0 and 5·7 per cent. more than the standard T. 1242. The increase in yield over the standard varied from 30·5 to 63·8 per cent.

(v) *Trial of Chinese introductions at Almora in Uttar Pradesh.*—Five early maturing Chinese introductions, were sent to Vivekananda Laboratory at Almora in Uttar Pradesh in 1955. These were grown under rain-fed condition at an elevation of 3,000 ft. and tested in a varietial trial against *Thapachini*, the local variety, as a standard. All the introductions were significantly better than the standard. Results are presented in Table XIII.

TABLE XIII

Performance of Chinese introductions at Almora (U. P.) in 1956-1957

Variety	Source	Yield in lb. per acre	% Over control
1. Chainan 8	China	3,560**	186·1
2. Kaohsinng 22	,,	3,544**	185·3
3. Chainan 2.	,,	3,264**	
4. Sinchu. 50.	,,	3,120**	
5. Taichung. 65.	Formosa.	3,064**	
6. Thapachini (Control).	U. P.	1,912	

**Significantly superior over Thapachini at 1 per cent. level of significance.

B.—*Hybridization*

(a) *Between japonica and indica rices.*—It has already been reported previously, that there were two parallel hybridization projects between the *japonica* and the *indica* rices, one sponsored by the F. A. O. and the other by the Indian Council of Agricultural Research, both of which terminated in March, 1956. The hybrid material available from these two projects, has been under study in its various filial generations, for the last six years. The progress of work in different generations is presented below.

(i) *F_2 generation.*—Thirty six-cross combinations, including two reciprocals were raised under normal fertility conditions, *i.e.*, 40 lb. N as Ammonium sulphate. Based on flowering duration and ear-bearing tillers, 460 field selections were made and finally on the basis of single plant yield and other grain characters, 132 selections were carried forward for further study in the next season. In general, due to late sowing, the yields of both the hybrids and the parents were low.

(ii) *F_3 generation.*—Forty-nine progenies from 14 cross combinations, were studied in a randomised replicated progeny row trial, with two replications and under two levels of fertility, viz., Normal fertility (40 lb. N as Ammonium sulphate and 18 lb. P_2O_5 as Super phosphate), and high fertility (70 lb. N as Ammonium sulphate and 54 lb. P_2O_5 as Super phosphate). Four random plants, in each progeny, were studied for 20 quantitative characters; the summary results obtained in the above study are presented in Table XIV.

TABLE XIV

Mean values of the various characters studied in F_3 of japonica-indica progenies raised in 1956-57

Serial No.	Character	*Indica* parents			Cross combination			% increase of crosses over *indica* parents	
		N. F.	H. F.	% increase of H. F. over N. F.	N. F.	H. F.	% increase of H. F. over N. F.	N. F.	H. F.
1.	Plant height (cms.)	125·8	136·2	8·3	132·1	142·4	7·8	5·01	4·55
2.	Total tillers per plant	22·6	24·2	7·0	19·4	23·5	21·1	—14·16	—2·9
3.	Ear-bearing tillers per plant	5·4	6·6	22·2	8·7	11·4	31·0	61·1	72·7
4.	% ratio of Ear-bearing tillers : Total tillers	30·0	33·0	10·0	45·3	49·0	8·1	51·0	48·5
5.	Flowering duration (days)	135·5	138·2	1·99	110·1	112·0	1·73	—18·75	—18·96
6.	Length of panicle (cm.)	23·0	23·6	2·6	21·8	22·2	1·8	—5·22	—5·93
7.	Total spikelets	105·7	114·2	8·0	109·8	109·1	—0·6	3·88	—4·47
8.	No. of fertile grains per panicle	77·2	81·2	5·1	78·0	73·8	—5·3	1·04	—9·11
9.	Density of panicle	4·53	4·8	5·9	4·9	4·87	—0·6	8·17	1·46
10.	500 grain wt. (gm.)	13·6	13·4	—1·4	12·5	12·4	—0·8	—8·09	—7·44
11.	Spikelet sterility per cent	28·0	28·3	1·0	29·0	32·2	11·00	3·57	13·78
12.	Plot yield of grain (oz.)	10·7	10·9	1·8	13·3	15·0	12·7	24·30	37·61
13.	Plot yield of straw (oz.)	33·6	44·1	31·2	33·3	35·0	5·0	—0·88	—20·63
14.	Straw/grain ratio	4·5	5·9	31·1	2·7	3·0	11·1	—40·0	—49·15
15.	Single plant yield (gm.)	8·44	8·59	1·7	10·48	11·82	12·1	24·17	37·60
16.	Hulling per cent	72·0	72·2	0·28	72·0	72·9	1·25	0·0	0·97
17.	Cooking quality	3·81	3·85	1·00	3·74	3·82	2·10	—1·84	—0·84
18.	Protein content	6·46	6·98	8·00	7·06	7·78	11·40	9·29	11·46
19.	No. of Single Plant selections made				58·	71	22·4		
20.	Mean Single Plant yield of selections (gm.)				29·0	32·0	10·3		

It was seen that among the hybrid progenies, there was a general increase in plant height, ear-bearing tillers per plant, ratio of ear-bearing tillers to total tillers, density of panicle, spikelet sterility, plot yield of grain, single plant yield and protein content, while there was decrease in flowering duration, total tillers, length of panicle, 500 grain wt., straw yield, straw grain ratio and cooking quality, over their respective *indica* parents, both under N. F. and H. F. For example in total tillers, there was about 14 per cent. decrease in the hybrid progenies on N. F.

Comparing the effect of fertility levels on parents and hybrid progenies it was seen that under high fertility conditions there was some increase in 14 out of 20 characters studies in both the parents and the hybrid progenies ; in three characters there was increase in parents while there was decrease in the hybrid progenies ; and there was slight decrease both in parents and hybrid progenies in 500 grain weight. Comparing the hybrid progenies with their parents, at H. F. there was 31 per cent. increase in ear-bearing tillers per plant and 12·7 per cent. increase in single plant yield over N. F., while in the parents it was 22·2 per cent. and 1·7 per cent. increase respectively. Thus the hybrids have given a better performance at H. F. over N. F., in the essential characters of the plant which contribute towards yield. Hybrids were also superior over the *indica* parents in most of the desirable characters both at N. F. and H. F.

Out of 365 field selections made both in N. F. and H. F., 49 selections from each of N. F. and H. F. were finally retained and carried forward for trial next year.

(iii) *F_4, F_5 and F_6 generations.*—Hybrid progenies, as well as parents from different filial generations, were grown in progeny row trials both under normal fertility (40 lb. N 18. lb. P_2O_5), as well as high fertility (60-80 lb. N 54 lb. PO_{25}) conditions. Field selections were made on the basis of flowering duration, plant height, tillering and panicle characters. These were studied in the laboratory and on the basis of single plant yield, spikelet fertility, grain characters and rice colour and a number of promising selections from each level of fertility were finally carried forward for further study next year. The experimental results are presented in a summary Table No. XV given below.

TABLE XV

Performance of japonica-indica hybrids in F_4, F_5 and F_6 generations

Filial generation.	Level of Fertility.	No. of cultures grown.	No. of cross combinations to which the cultures belong.	No. of cultures superior over *indica* parents.	No. of field selections made.	No. of final selections carried forward to next year.
F_4 (from I.C.A.R. Scheme).	N. F.	102	18	22	1,844	7
F_4 ,,	H. F.	88	24	12	1,460	6
F_4 (from F.A.O. Scheme).	N. F.	101	9	21	550	7
F^4 ,,	H.F.	125	14	21	455	7
F^5 ,,	N. F.	120	13	9	1,700	5
F_5 ,,	H. F.	107	28	2	1,300	5

TABLE XV—*contd.*

Performance of japonica-indica hybrids in F_4, F_5 and F_6 generations—contd.

Filial generation.	Level of Fertility.	No. of cultures grown.	No. of cross combinations to which the cultures belong.	No. of cultures superior over *indica* parents.	No. of field selections made.	No. of final selections carried forward to next year.
F^6	N. F.	217	42	81	2,335	118
F^6	H. F.	187	48	61	1,656	125

Between the two levels of fertility, the mean plot yield of the hybrid cultures was 25·7 oz. under N. F. and 20·1 oz. under H. F., an increase of 27·2 per cent. of N. F. over H. F. Among the cultures at the two levels of fertility in general the cultures at N. F. yielded higher than those under H. F., however, one culture viz., HS. 19× Taihoku. 6 JI276-51-42-1 gave 17 per cent. more yield under H. F. than the same under N. F. Six cultures from N. F. and five cultures from H. F. will be tested in a bulk trial next year.

Bulk trial of japonica × indica *F_6 cultures*—

There were two trials :—

(*a*) Nineteen cultures from 19 cross-combinations were grown in a split design under two levels of fertility, *viz.*, N. F. (40 lb. N 18 lb. P_2O_5) and H. F. (120 lb. N 54 lb. P_2O_5). There were four replications. Between the levels of fertility, the N· F. gave significantly higher yield than the H. F., increase being 31·4 per cent.

At N. F., 2 cross-combinations, *viz.*, *Geb. 24* × *Aikoku* and *Geb. 24* × *Taichu. 65*, yielded 2620 lb. and 2331 lb. per acre respectively, which was significantly more than the yield of the *indica* parent ; which gave 1552 lb. per acre, increase over *indica* parent being 68·7 and 50·0 per cent. respectively.

(*b*) Eleven cultures comprising of six cross-combinations, were tried in the same way as above, except that in H. F. a dose of 80 lb. N instead of 120 lb. N per acre was applied. Between the two levels of fertility, the mean plot yield under N. F. was significantly higher by 31·0 per cent. than that in H. F. On the mean of the two levels of fertility, two cross-combination, *viz.*, *Norin. 6* × *Geb. 24* and *T. 1145* × Asahi, yielded 4·0 per cent. and 9·0 per cent. respectively, more than their respective *indica* parents ; the latter yielded 998 lb. and 1166 lb. per acre respectively.

(*i*) *Within indica rices.*—This breeding project, as previously reported, has been undertaken to evolve early-maturing, high-yielding strains. During the year the performance of 250 selections, with medium coarse grain, belonging to 7 cross-combinations and 125 selections with fine grain, belonging to two cross-combinations, involving three early-maturing, and 4 late-maturing varieties, were tested in two randomised replicated progency row trials. Results showed, that 24 cultures with medium grain were as good as the high yielding parents, *T. 1242* but were earlier than *T. 1242* by 21-34 days. Six cultures with fine grain yielded 2468 lb. to 2933 lb. per acre which was significantly more by 22·8 to 45·9 per cent., respectively, than the control *T. 608*, which gave 2006 lb. per acre. The performance of 18 best cultures from the two grain groups are given in Table. XVI.

TABLE XVI

Performance of Early × High Yield F_5 cultures 1956-57

Serial No.	Cross	Culture No.	Calculated yield per acre in lb.	Per cent over control	Flowering duration in days	Grain quality
1.	T. 1242	Parent	2634	100·0	137	Medium coarse
2.	T. 90 × Sathika	170-319-92-138-20	2439	92·58	110	,,
3.	T. 1145 × Ch. 2	42-72-48-44-38a	2351	89·25	106	,,
4.	T. 1145 × Ch. 2	42-76-95-2-1	2293	87·05	105	,,
5.	T. 1145 × T. 1031	54-110-38-8-13	2293	87·05	105	,,
6.	T. 1145	Parent.	2278	86·48	114	,,
7.	T. 1145 × CH. 2	42-76-95-72-1	2264	85·95	102	,,
8.	T. 90 × Sathika	170-319-92-138-19	2250	85·41	109	,,
9.	T. 90 × Sathika	170-319-92-138-38	2250	85·41	112	,,
10.	T. 812 × T. 1031	196-346-8-11-1a	2237	84·65	110	,,
11.	T. 90 × Sathika	170-319-92-138-19a	2230	84·65	110	,,
12.	T. 90 × Sathika	170-319-92-98-20a	2210	83·91	97	,,
13.	T. 90 × Sathika	170-322-22-42-15	2933	145·92	101	Fine
14.	T. 90 × T. 1031	161-303-73-59	2756	137·13	103	,,
15.	T. 90 × Sathika	170-322-22-43-1	2708	134·73	102	,,
16.	T. 90 × T. 1031	161-303-73-2-38	2533	126·08	99	,,
17.	T. 90× T. 1031	161-303-10-2-56	2478	123·21	100	,,
18.	T. 90 × T. 1031	161-303-73-34-77	2468	122·80	100	,,
19.	T. 608	Parent	2006	100·0	102	,,

(ii) *Bulk trial of promising F_7 cultures.*—Sixteen cultures from medium grain roup, and nine from fine grain group were tested in two randomised replicated rials against six standard varieties. In the medium group, 12 cultures yielding etween 2343-2041 lb. per acre were as good as *T. 141* (a high yielding 440 lb. per acre, medium duration variety), but were 14-22 days earlier than *T. 141.* One culture, *viz., T. 1145 × Ch. 2-42-76-95-2-1* yielded 2343 lb. per cre which was 19·1 per cent. significantly more than the yield of *T. 1145* 1968 lb. per acre) ; this culture was 13 days earlier than *T. 1145.* In the fine grain group, three cultures, *viz., T. 90 × T. 1031-161-303-7-18, T. 90 × Sathika-170-322-22-5* and *T. 90 × Sathika-170-322-22-42* yielded 1930, 1912 and 1912 lb. per acre, respectively, which was significantly more than the yield of T. 608 (1694 lb. per acre), a fine grained early maturing local standard variety, increase being 13·9, 12·9 and 12·9 per cent. respectively.

(iii) *Second crop (December-April) trial of promising cultures.*—Twenty-nine cultures from medium grain group and 35 from fine grain group, were tested in two replicated randomised block trials against local standard varieties in the second crop season.

In the medium grain group, 14 cultures yielded 2230 lb. to 2852 lb. per acre, which was 19·35 to 28·79 per cent. more than the yield of *B. 76* (a high yielding coarse grained red kernelled variety), which yielded 2214 lb. per acre. Two of these cultures, *viz., T. 90 × Sathika-170-319-92-138-3* and *T. 812 × Sathika-196-346-8-11-1*, yielded 2852 lb. and 2643 lb. per acre respectively, which was 28·79 and 19·0 per cent. significantly more than the standard *B. 76.* In the fine grain group, 29 cultures yielded more than the control, *T. 608* (1252 lb. per acre) and one of them, *viz., T. 90 × Sathika-161-303-73-34-68* yielded 1646 lb. per acre which was 31·32 per cent. higher than the standard. Thus some of the cultures are suitable for growing in the Second crop season as well.

C. *Selection*

With a view to evolve high-yielding strains in some of the popular Chinese introductions as well as in the *Basmati* rices, secondary selections were made in two Chinese varieties, *viz., Ch. 13* and *Ch. 45* and in *Basmati* rices received from four sources, *viz.*, Dehradun, Punjab, Himachal Pradesh and Kulu Valley. Results of selection are presented below.

I *Chinese varieties*

Ten selections in *Ch. 45* and *15* in *Ch. 13*, were tried against their respec tive bulks in a replicated progeny row trial. Twenty progenies yielded better than their respective bulks and three of them—one in *Ch. 13 viz.* Culture 39-2-17 and two in *Ch. 45, viz.*, cultures 26-40-32 and 26-40-28 yielded 2383, 1410 and 1316 lb. per acre respectively, which was significantly more than the yields of *Ch. 13* (1813 lb. per acre) and *Ch. 45* (861 lb. per acre) the increase over the original bulk being, 31·5, 63·5, and 57·9 per cent. respec tively. Forty single plant selections have been carried forward for further study.

II *Basmati rices*

One hundred and fifty selections from 30 progenies were tested in a compact family block trial against the original bulks. Seven families—3 from Himachal Pradesh, 2 from Punjab and 2 from Kulu Valley yielded significantly better than their respective bulks, increase being 41-220

per cent. Within the families, differences between the progenies were significant and 14 progenies were found to yield significantly more than the others. Fourteen progenies, with five selections in each, will be further tested in the coming year.

III. *Breeding for upland conditions*

The performance of 47 early maturing (within 110 days) varieties, including 10 promising homozygous cultures from early × high yield crosses, were tested in a preliminary yield trial under purely rainfed conditions, against the local variety *B. 76-116*, as standard. Two varieties, *viz.*, *W. 367* and *W. 627* yielded 2532 lb. and 2509 lb. per acre respectively and were significantly superior to the standard (1951 lb. per acre). Besides these two, ten more varieties, including five hybrid cultures were on par with the standard.

In the second trial, seven promising varieties carried forward from previous year's trial were tried against *B. 76-116* as standard. *T. 657* (a variety from Bengal) yielded 2593 lb. per acre, and was significantly superior to the standard *B. 76-116* (2191 lb. per acre).

IV. *Breeding for non-lodging habit and high yield*

Most of the Indian rice varieties are weak-strawed and are therefore susceptible to lodging resulting in considerable loss in yield. An Indian Council of Agricultural Research Scheme for breeding non-lodging varieties is in progress since September, 1956. During the year, 15 varieties reported to be non-lodging were tested in a varietal trial under heavy fertility conditions.

Fifteen stiff-strawed varieties, comprising of 14 foreign and one Indian variety, were tested for their non-lodging habit and yield in a preliminary yield trial against *T. 141* (a high yielding, medium duration and week-strawed type) as standard. They were grown in a low lying area, under heavy fertility conditions (100 lb. N as ammonium sulphate 54 lb. P_2O_2 as super phosphate). Except the standard *T. 141*, no other variety lodged. Three of the non-lodging varieties, *viz.*, *AC. 1951*, *W. 130* and *W. 113* yielded 2463, 2255 and 1754 lb. per acre which was 108·5, 90·9 and 48·5 per cent. significantly more than the yield of the standard *T. 141* (1182 lb. per acre). These varieties will be further tested next year.

The performance of 72 selections, made previously in the non-lodging varieties, were tested in two replicated progeny row trials —32 in the first and 40 in the second trial.

In the first trial, three cultures, *viz.*, *W. 215-2-75*, *AC. 1951-2-18* and *CI. 8985-3-42* yielded 976, 1883 and 1179 lb. per acre and these were significantly superior to their respective bulks by 98·2, 99·8 and 72·3 per cent. respectively. Of these, one culture, *viz.*, *AC. 1951-2-18* yielded significantly better than T. 90 and B.A.M. 9, the high yielding local standard varieties. This culture gave 13·81 per cent. higher yield than *T. 141* (1655 lb. per acre), another high yielding medium maturing, local variety. This selection, *viz.*, *AC. 1951-2-18* will be used in further trials in place of the original AC. 1951.

In the second trial, two selections, *viz.*, *W. 113-2-36* and *W. 139-1-27*, yielded 1521 lb. and 1624 lb. respectively per acre which were 50·5 and 52·8 per cent. significantly more than the yield of their respective bulks. Both

these cultures yielded 9·0 — 45·0 per cent. more than the three high yielding local varieties, *T. 90*, *B.A.M. 9* and *T. 1242*. One of the cultures, *viz.*, *W. 130-1-27* yielded 44·8 per cent. significantly more than *T. 1242* (1121 lb. per acre). These selections will replace the original bulks in future study.

V. *Estimation of loss due to lodging*

T. 141, which lodged five days after flowering, was propped up in half the plots, for estimation of loss due to lodging. Results showed that there was 34·7 per cent. loss in yield due to lodging at this stage.

Study of F_2 population of crosses between improved Orissa varieties and non-lodging varieties.—Thirteen cross-combinations, comprising of crosses between four improved Orissa varieties, *viz.*, *T. 90*, *T. 141*. *T. 1242* and *B.A.M. 9* and one Chinese variety *Ch. 45* on the one hand, and six non-lodging varieties, *viz.*, *AC. 1951*, *Puang-Nak*, *Nom-Dok-MI*, *AC, 517*, *W. 220* and *W. 113* on the other, were studied. Besides these, 8 natural crosses in *CI. 8985*, *W. 113*, *W. 214*, *W. 220* and *W. 221* were also studied. All these were grown under high fertility conditions (100 lb. N as ammonium sulphate 54 lb. P_2O_5 as superphosphate). Based on plant habit, number of ear-bearing tillers per plant and duration, 488 field selections were made, out of which 223 selections, giving at least 25 per cent. more yield than the high yielding parent, were retained for further study next year.

VI. *Breeding for resistance to blast and Helminthosporium*

As mentioned last year, work in collaboration with the Mycologist is in progress for breeding high yielding, early and medium duration strains resistant to blast and *Helminthosporium*, the two most important diseases of rice crop.

During the year, 204 selections combining blast resistance and good yield from the cross *Co. 13*×*Co. 25*, the susceptible and resistant parents respectively was grown in F_2, F_3, F_4, F^5 and F^6 generations. The seed beds were heavily manured. Resistance of the cultures was examined at seedling stage, profuse tillering stage and at maturity, and those resistant at all these stages were further examined for other characters. In the F_2 generation 7 families of the cross *Co. 25*×*Co. 13* and its reciprocal were grown, and based on resistance to blast, early maturity (120-125 days) and good yield, 34 selections out of 53 field selections, were retained for further study. In the F_3 generation, 85 cultures were raised. Out of the 135 field selections, 50 selections combining early to medium maturity period, disease resistance and good yield, were finally carried forward.

In the F_4 generation, 88 cultures were grown in a replicated progeny row trial ; 35 progenies yielded singificantly better than *Co. 13* (1049 lb. per acre), their yield ranging from 1489 lb. to 3176 lb. per acre. Out of the 152

selections made in the field. 36 selections combining resistance to blast single plant yield between 30·0 and 55·0 gm. and ranging in duration from early to late were finally selected.

In the F_5 generation 29 cultures were grown in a replicated progeny row trial. Except one the remaining produced 1477 lb. to 4626 lb. of grain per acre. which was significantly better than the yield of the standard *Co. 13* (432 lb. per acre). Most of these cultures were of early duration maturing between 120-130 days. Out of 461 field selections 59 selections based on resistance to blast and single plant yield between 39 and 80 gms. were finally carried forward.

In the second crop season 34 cultures in F_3, 8 in F_4, 24 in F^5 and 11 in F^6 generations were grown and a total of 40 selections were finally carried forward. Due to unfavourable environmental conditions of the second crop season the performance of most of the cultures was of a lower order than that of the same cultures in the main crop season.

In the project on breeding varieties resistant to *Helminthosporium* five F_2 families of the cross between *BAM. 10* (resistant to *Helminthosporium*) and *Co. 25* (susceptable to *Helminthosporium*) along with the two parents were raised and studied. Based on resistance to the disease single plant yield and early-to-medium maturity 10 selections were finally carried forward for further study.

VII. *Breeding for high yield and good quality grain*

This project was undertaken to evolve high yielding, early maturing, fine quality rice with white kernel. For this purpose *Ptb. 10* a high yielding but red-kernelled variety was crossed with *N. 136* a fine white kernelled variety was crossed with *N. 136* a fine white kernelled variety and *Ch. 45* a good yielding medium coarse white kernelled variety in 1953. During the year 43 cultures in F_3 generation and 61 in F_4 generation of crosses *Ptb. 10*×*Ch. 45* and *N. 136*×*Ptb. 10* were grown. Based on good yield early maturity rice colour and fine to medium grain 28 selections from F_3 and 55 from F_4 generation yielding over 30 gm. per plant were finally selected and will be studied next year.

VIII. *Genetics*

Work is in progress to study the inheritance of morphological characters. The anthocyanin pigmentation in various parts the number of genes controlling the expression of these characters and the interrelationship of the pigment genes with each other and with those controlling other morphological characters. Results are presented below.

(*a*) *Morphological Characters*

(i) *Inheritance in dwarfism.*—The Institute has a collection of 15 dwarf types comprising of 5 from Japan, 3 from U.S.A. and 7 from India. They are being intercrossed to study the number of genes

involved in different dwarfs and their interrelationship with each other. In the crosses *D.6-24* (dwarf)×*AC.806* (normal) *T. 432* (dwarf)×*T.1242* (normal) and *T. 432* (dwarf)×*T. 90* (normal) the F_2 segregated into ratios of 3 : 1, 15 : 1, 54 : 10, of normal to dwarf respectively. The 3 : 1 and 54 : 10 ratios were confirmed by F_3 results.

(ii) *Inheritance of auricle, ligule and junctura.*—The absence of auricle, ligule and junctura a mutation found in the variety *Shala* from Kashmir, was studied in the cross between *Shala*×*Salak* (a variety from Indonesia possessing long auricle, long ligule and junctura) and was found to be governed by four duplicate genes each capable of producing the three organs in question. The genes for ligule size were found to have an additive effect on the length of ligule. It was also found that all the three characters were inherited as a unit. The F_2 hypothesis was confirmed by F_3 results.

(iii) *Length of sterile glume.*—In the cross between *AC. 1225* (a long glumed variety) and *AC. 806* (a short glumed variety) the F_1 was short glumed and the F_2 gave a monogenic segregation of 3 normal :1 long glume.

(iv) *Awning.*—In the cross between *Shala* (awned) and *AC. 806* (awnless) the F_1 was awned and the F_2 segregated into a ratio of 54 awned : 10 awnless showing the interaction of 3 genes any two of which could produce awns.

(v) *Multiple pistil.*—*AC. 1225* is multipistillate while *AC. 806* is unipistillate. In a cross between the two the F_1 was unipistillate and the F_2 gave a trigenic ratio of 54 unipistillate : 10 multipistillate. The F_2 hypothesis was confirmed by F_3 results.

(vi) *Shape of kernel.*—Variety *AC. 1107* has a notched kernel, while variety *AC. 806* has a normal kernel with un-notched periphery. In a cross between the two varieties the F_1 was un-notched and in the F_2, a ratio of 229 un-notched : 27 notched kernel was obtained. This was explained on the assumption that of the four genes concerned in the inheritance of notched character one was an inhibitory factor which suppressed the expression of the notched condition of the kernel.

In general there was no linkage between the above morphological characters and the presence or absence of anthocyanin pigmentation in various plant parts, except in the case of presence of pigment in the apiculus and the presence of auricle, ligule and junctura, where linkage with a C.O. value of 29·66 was found between the two characters. The genes for auricle , ligule and junctura were confined to Jodon's combined linkage groups II and III.

(*b*) *Anthocyanin pigmentation.*—Inheritance of anthocyanin pigmentation was studied in 14 plant parts involving 8 cross combinations. The F_2 segregations obtained are summaried below :—

Pigment in	F_2 segregation	
1. Leaf sheath	3:1 ; 9-7 ; 117:139 ; and 162:94 of pigment : no pigment.	
2. Leaf axil	3:1 ; 45:19 ; 27:37 and 162:94	do.
3. Auricle	3:1 ; 9:7 ; 27:37 and 117:139	do.
4. Ligule	9:7 ; 27:37 ; and 117:139	do.
5. Junctura	9:7 ; 15:1 ; 45-19 and 162:94	do.
6. Leaf blade	3:13 ; 9:55 and 162:94	do.
7. Tip and margin	9:7 ; 27:37 and 45:19	do.
8. Pulvinus	9:7 ; 54:10 and 162:94	do.
9. Septum	3:1 ; and 9:7	do.
10. Internode	3:1 ; 9:7 ; 117:139 and 81:175	do.
11. Glume	3:1 ; 9:7 ; 27:37 and 117:139	do.
12. Apiculus	3:1 ; 45:19 and 162:94	do.
13. Stigma	9:7 ; 15:1 ; 81:175 and 162:94	do.
14. Kernel	3:1 and 45:19	do.

(*c*) *Interrelationship of pigment genes.*—Some pigment genes were found to exhibit pleiotropic effect in different cross combinations *e.g.*, Ntp_1=Lsp_1 : Ap_1=Lsp_1 ; Ap_2=Lsp_2 and Sp_1=Lp_2. The *Ntp* gene for pigment in internode and *PO.* gene for red kernel were found linked with a crossover value of 36·5 per cent.; similarly the *Ntp* gene and *Prp*, gene (purple pigment in kernel) were found linked with a crossover value of 5·06 per cent.

(*d*) *Heterosis in rice.*—Fourteen cross combinations involving six varieties *viz.*, *JBS. 66*, *JBS. 102*, *JBS. 118*, *JBS. 120*, *JBS. 294* and *JBS. 568*, collected from the Jeypore tract of Orissa and three varieties from the genetic stocks, *viz. W. 506*, *AC. 2562* and *AC. 2605* were studied in the F_1 generation for various characters. Results indicated that in most of the hybrids there was considerable increase in the number of ear-bearing tillers per plant, number of fertile grains per penicle and single plant yield, over the mean of the two parents. Results are summarised below.

TABLE XVII

[Showing the frequency of distribution of various morphological characters in the Wild types collected]

F_2 Cross combination	No. of fertile grains per 5 panicles		Mean ear-bearing tillers per plant		Single plant yield (gm.)		Per cent of hybrid over the parental mean		
	Hybrid	Parental Mean	Hybrid	Parental Mean	Hybrid	Parental Mean	Fertile grains per 5 panicles	Ear-bearing tillers per plant	Single Plant Yield
1. W. 506×JBS. 66	425	178	29·0	17·8	38·5	10·3	238·7	162·9	373·7
2. W. 506×JBS. 102	603	269	19·0	23·5	21·7	22·2	224·1	80·8	97·7
3. W. 506×JBS. 118	398	256	27·0	23·5	37·7	16·1	155·4	114·8	234·1
4. W. 506×JBS. 120	499	359	18·0	25·0	34·8	18·3	138·9	72·	190·1
5. W. 506×JBS. 294	319	283	22·0	24·65	47·3	25·5	112·7	89·2	185·4
6. AC. 2605×JBS .66	377	305	29·5	20·8	35·8	16·0	123·6	141·8	223·7
7. AC. 2605×JBS. 102	389	396	36·3	26·5	57·0	28·0	98·2	136·9	203·5
8. AC. 2605 × JBS. 118	510	383	30·0	26·5	39·8	21·9	133·1	113·2	181·7
9. AC. 2605 × JBS. 120	335	486·5	28·0	28·0	40·2	24·0	68·8	100	167·5
10. AC. 2605 × JBS. 568	519	371·5	24·3	26·2	41·8	27·5	139·7	92·7	152·0
11. AC. 2562 × JBS. 66	562	295·5	19·0	19·8	31·7	15·0	190·1	95·9	211·3
12. A.C. 2562 × JBS. 102	337	386·5	38·5	25·5	44·0	27·0	87·1	150·9	162·9
13. AC. 2562 × JBS. 118	836	373·5	23·0	25·5	47·5	20·9	223·8	90·1	227·3
14. AC. 2562 × JBS. 120	329	476·5	29·0	27·0	41·5	23·0	69·04	107·4	180·4
15· AC. 2562 × JBS. 568	442	361·5	26·0	25·2	33·0	26·5	122·2	103·1	124·5

IX. *Embryo culture*

Embryos of ages varying between 5 days and 10 days were artificially cultured in Randolph's nutritive medium containing 2 per cent. and 5 per cent. sucrose. Results showed that embryos of ages 7 days and above could be easily cultured on the above nutritive medium, while those below 7 days failed to germinate. There were no visible differences between the embryos cultured in 2 per cent. and 5 per cent. sucrose. Rate of growth was found to be positively correlated with the age (upto 10 days) of the embryo cultured.

X. *Cytology*

Interrelationships of species in the genus oryza.—New additions to the species collection included a new species *Oryza ridleyi* from Malaya and five new varieties of species in the collection namely *O. officinalis*, *O. latifolia* and *O. alta*. Data from cytology morphology and crossability were collected for tracing interrelationships.

In the new additions was a wild species from Ceylon labelled as *O. latifolia* received through the United States Department of Agriculture. This had short unfringed ligules and its chromosome number was 2N=24. These two features showed that the species was not *O. latifolia* and it was reclassified as being *O. officinalis*. In comparison to *O. officinalis* from Assam, the Ceylon type differed in its indeterminate flowering habit and in having longer spikelets, and is probably a geographical variety. This taxonomic work supports the view that *O. latifolia* does not occur in Asia.

Three types of *O. latifolia* from America, (the Guianas and Gautemala) were compared with *O. latifolia* from Cuba and *O. alta* from Paraguay. All were tetrapoloide (2N=48), but the new varieties were intermediate between the two species in the taxonomic characters namely, leaf lamina width and spikelet dimensions. This range of variation shows *O. latifolia* and *O. alta* were allied species and they could even be considered as geographical varieties of a single species. One natural cross between the two species was however highly sterile showing that genetic barriers to intercrossing were present.

O. ridleyi was a shade requiring species without rhizomes and was highly sterile under Cuttack conditions. It was found to be a tetraploid, showing abnormalities at meiosis namely one to two quadrivalents, anaphase bridges as well as degeneration of pollen tetrads. Vestigial anthers without pollen were also observed in many spikelets. This species resembled *O. granulata* in adaption to shade in habit in leaf shape and in panicle characters. It is probable that this species had evolved from the diploid *O. granulata* by hybridization and polyploidy.

Studies on the interrelationships between *O. perennis* and the cultivated species *O. sativa* was continued. *O. perennis* is closely related to cultivated rice as the two species can be hybridized and fertile progeny secured. The varieties of *O. perennis* studied were *O. perennis* var. *Balunga* (from Orissa), *O. perennis* var. *cubensis* (from Cuba), *O. perennis* var. *Barthii* (from West Africa) and *O. perennis* var. *Sudanense* (from Sudan obtained this year). The type from Sudan was 24 chromosomed and closely alike to *O. perennis* var. *Barthii* and differed only in the pigmentation of spikelets. Neither of these set seed when crossed to *O. sativa* nor when intercrossed. Both the varieties

showed adaptation to cross pollination as shown by the seed setting being reduced to nil when bagged, from the 10 to 50 per cent. setting under open pollinated conditions. Both the varieties were strongly rhizomatous.

The Orissa variety *O. perennis* var *Balunga* has only a short rhizome but has floating branched stem. It crosses freely with cultivated rices *O. sativa* and *O. glaberrima*. A survey of rice fields near Cuttack showed that this species which is common in pond margins and ditches crosspollinates the cultivated rice and the natural hybrids occur both in fields as well as in ditches. Experimental work to confirm the hybrid origin of wild rice weeds has been started.

In the study of varietal differences in the species *O. perennis* the Orissa variety and Cuban variety were crossed. The hybrid showed semisterility.

Cytology of O. sativa.—A naturally occurring triploid of the variety *T. 1242* was grown by vegetative propagation. As the plants were sterile only few seeds were secured from them and these only three seedlings could be raised. The three plants were anueploids having the somatic chromosome numbers 26, 26 and 28. Another anueploid was secured from the progeny of X-ray irradiated plants. In this the somatic chromosome number was 25 and it was identified as a tertiary trisomic by the occurrence of either a pentavalent or a trivalent at meiosis.

Differentiation of cultivated rice into subspecies.—Work started previously on the genetics of semi-sterility in the progeny of *japonica* × *indica* hybrids was completed. The incidence of spikelet sterility showed the following features. The sterility in the F_1 generation varied with the parental combination and could not be correlated with external characters. The extent of sterility in the F_1 generation varied with environmental conditions. The sterility in the F_2 generation showed a large range of variation some plants being more sterile than the F_1 parent. True breeding fully fertile plants were not found in the F_2. Selection for semisterility and for fertility was effective from F_2 generation onwards. Segregations for fertility continued even in F_6 generation. True breeding semisterile plants could be secured by selection. In general abnormalities of chromosome behaviour at meiosis were of low frequency and would not account for the extent of sterility present.

In this study a completely homozygous plant was secured from the F_8 of the cross Riku 132 (*japonica*) × Myang Ebos (*Indica*) in the following way. A naturally occurring haploid plant was colchicine treated diploid tillers secured and homozygous seeds collected. This culture showed slight semisterility in the main season and increased semisterility in the second crop season. These observations show that heterozygosity cannot be the sole cause of semisterility and also that genetic factors control response to environment in semisterility also.

The following explanation would fit in with observed mode of inheritance. The physiology of the plant or its adaptation to a given environment is the main factor in expression of sterility. Since the parents are adapted to markedly different environments, the segregating progeny would show segregation for adaptation to a given environment. The other chromosomal and genic factors are additive to the physiological factor in causing semisterility and mask its expression.

The differentiation of indica and japonica subspecies of rice are to be correlated to selection and adaptation for different ecological conditions.

XI. *Jeypore Botanical Survey Scheme*

During the last year parts of Jeypore tract; consisting of Malkangiri and Jeypore Taluks of Koraput district (Orissa) were explored. Seed samples of 709 cultivated types from 183 villages, 22 wild types (*O. sativa* var *fatua*) and one species (*O. granulata*) were collected.

During the year under report (1956-57) parts of Nowrangpur and Koraput taluks and the adjoining areas of Bastar district of Madhya Pradesh and Kalhandi district of Orissa and some parts of Malkangiri taluk, which were not surveyed during the previous year, were surveyed. In these areas 363 seed samples of cultivated types from 146 villages and 90 wild types (*O. sativa* var *fatua*) from the adjoining forest areas were collected. Of these 90 samples of wild types, 77 were collected in the form of seeds and the rest 13 as clumps. Thus during the above two years a little over 2/3rd of the entire tract has been covered and in all 1072 samples of cultivated rice (*O. sativa*) and 113 samples of wild rice (*O. sativa* var *fatua*) and one sample of *O. grabulata* have been collected. Of these collections, 13 were pigmented types and 41 scented.

TABLE XVIII

Details of collection

Years	Locality	Anchal	Varieties collected		Remarks
			Cultivated	Wild	
1	2	3	4	5	6
1955-56	Kotpad	Borigumma	100	15	*O. sativa* var. *fatua*
	Borigumma & Kusumi	,,	71	7	do.
	B. Singpur, Kumuli and Ranigadda	,,	90	1	*O. granulata*
	Govindapalli and Mathili	Malkangiri	125	..	
	Malkangiri	,,	91	..	
	Bejangwada	,,	9	..	
	Kalimella, Motu and Podia	,,	117	..	
	Jeypore	Jeypore	106	..	
1956-57	Nowrangpur	Nowrangpur	191	69	*O. sativa* var. *fatua*
	Umerkote	Umerkote	31	7	do.
	Chandahandi	Umerkote	13	..	
	Jhorigam	Umerkote	2	..	..
	Sunki	Nandpur	10	..	..

TABLE XVIII—*contd.*

Details of collection—contd.

Years	Locality	Anchal	Varieties collected: Cultivated	Varieties collected: Wild	Remarks
1	2	3	4	5	6
1956-57 —*contd.*	Pottangi	Nandpur	14	1	*O. sativa* var. *fatua*
	Nandpur		7	..	..
	Padwa		1	..	..
	Machhakund		2	..	..
	Lambtaput		8	..	..
	Koraput	Koraput	20	1	*O. sativa* var. *fatua*
	Kakrigumma		7	..	..
	Narayanpatna		30	2	do.
	Almanda		2	10	do.
	Ballimella	Malkangiri	14	..	..
	Mathili		3	..	..
	Kotpad	Borigumma	7	..	..
		TOTAL	1,072	113	

The above collection was studied for grain character. They were measured for their grain size, and grouped into five classes according to their length, three classes, according to their width, and into two on the basis of their shape index, *i.e.*, length/breadth ratio. Twenty-one types were fully awned, 28 partially awned and 314 were awnless. The ripening colour of lemma and palea and the nature of the sterile glumes were studied.

Seven hundred and nine seed samples collected during 1955-56 were given in the field and observations were recorded on duration and sterility per cent., single plant yield, weight, and volume of 1,000 grains. The collection was classified into different grades on the basis of grain size and shape, weight, volume. Four hundred types out of the collection were more intensively studied and detailed observations recorded on their botanical characters, *viz.*, stem, internode, leaf, panicle, lemma and palea, apiculus, awn, floral structure and grain character.

Wild varieties of Balungas.—The collection included 112 samples of *O. sativa* var. *fatua* commonly called *Balunga* and one sample of *O. granulata*. As pointed out in the previous year, with regards habit *O. sativa* var. *fatua* can be grouped under 3 types, *viz.*, prostrate, semierect and erect. The seed samples were studied for their length, breadth, shape index, colour, nature of awn, ripening colour of lemma and palea, nature of the kernel, etc., and are given in Appendix I. The study of the wild types revealed that the grains ranged from very coarse to very fine. The grain breadth ranged from narrow to very broad. The ripening colour of lemma and palea fell under 8 groups with many intergrades. Awning character ranged from long awns to complete absence.

APPENDIX I

Showing the frequency of distribution of various morphological characters in the Wild types collected

—	Length of grain					Breadth of grain			Shape Index		Awn			Length of sterile glume			Ripening colour of lemma & palea									Nature of kernel		
	Very short	Short	Medium	Long	Very long	Narrow	Medium	Broad	Oblong	Oval	Long Awn	Short Awn	Awn less	As long as lemma and palea	½ of lemma and palea	1/3 or less of lemma and palea	a1	a4	b	c	e	f	j	k	Inter Grade	Glutinous	Non-Glutinous
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1955-56	—	2	17	3	—	9	3	10	11	11	18	2	2	—	—	22	1	4	1	—	1	5	—	9	1	—	22
O. granulata	1									1			1			1	1	1									1
1956-57	*nil*	1	36	38	2	*nil*	22	55	27	50	73	2	2	*nil*	*nil*	77	7	5	4	2	—	3	19	5	32	—	77

CHEMISTRY

I. *Availability of nutrients under the water logged soil condition*

(*a*) Investigations were carried out to estimate the availability of fertilizer nitrogen from urea applied to soil, at intervals of 1, 2, 3, 5 and 7 days before flooding. Urea was applied to soil in the semi-dry state, at the rate of 100 mg. N per pot, which contained 3 kg. of rice soil. Application of urea, just prior to flooding and immediately after flooding was also tried. Fertilizer nitrogen losses in drainage water during a period of 18 days of flooding and fertilizer nitrogen recoveries in soil after this period were estimated. The data are given in Table XIX.

TABLE XIX

Nitrogen losses in drainage and nitrogen recovery in soil from urea applied to flooded soil

Time of urea application	Fertilizer N lost in drainage (per cent of total added)	Fertilizer N recovered in soil after 18 days of flooding (per cent of total added)
1. 7 days before flooding	34	33
2. 5 days before flooding	34	33
3. 3 days before flooding	..	66
4. 2 days before flooding	..	75
5. 1 day before flooding	..	90
6. Applied just before flooding	..	93
7. Applied after flooding	..	72

Nitrogen lost in drainage was mostly in the form of nitrate nitrogen and that present in the soil was predominantly in the ammonium form. It was seen that when urea was applied to soil just before flooding or 24 hours before flooding, about 90 per cent of the applied nitrogen was present in the soil even after 18 days of water logging. A considerable amount of nitrogen was however lost due to drainage and denitrification when urea was applied 2-7 days before flooding and losses were more with increase in interval of application before flooding. Urea applied to soil after water-logging also showed low recovery of fertilizer nitrogen. It is therefore recommended that urea should be applied, well mixed with soil, about 24 hours before flooding. Urea applied earlier or after flooding is likely to give low fertilizer efficiency.

(*b*) During the last year a sampling technique was described, for getting a representative sample of water logged soil for chemical analysis. This technique was employed during the current year to get samples from two

typical soils, viz., Clay and Clay loam, in the Central Rice Research Institut farm area, for estimation of available nitrogen in the soil. Sampling erro likely to occur due to personal equation by two different persons was estimated The moisture percentages of the soil sampled by two different persons ar given in Table XX below. This sampling technique is now being successfull employed in investigations to determine the nitrogen status of water logge soils during the growth period of crop.

TABLE XX

Mean value of moisture per cent of soil samples collected from different field about 30-40 cents in area

Soil type	Sampler No. 1		Sampler No. 2	
	Moisture per cent	S. D.	Moisture per cent	S. D.
Clay	44·8	±2·7	43·1	±2·6
Clay loam	36·8	±1·5	36·5	±2·5

II. *Investigations on nitrogen nutrition of rice in relation to plant growth an crop yield*

(*a*) Influence of graded levels of N, P_2O_5 and K_2O on yield and composition of rice crop was studied under solution culture technique with two varieties Ptb. 10 during the first crop season and GEB. 24 during the second crop season Each of these nutrients was tried at 0, 5, 10, 20, 40, 60, 100, 150 and 200 ppm in three separate trials for N, P_2O_5 and K_2O respectively. In each trial, othe nutrients were kept at optimum level. It was seen that optimum level o nitrogen for grain yield was about 30-40 ppm. At lower nitrogen levels grain yield was reduced because of nitrogen deficiency. At higher nitroge levels also, the grain yield was pulled down and there was excess of nitroge in the straw and grain, which resulted in more straw yield in comparison t grain yield.

Optimum level of phosphate for grain yield ranged from 5 to 10 ppm At phosphate levels over 60 ppm., crop growth was considerably retarde due to phosphate toxicity in the tissue, where very high phosphate concentra tion accumulated, particularly in the straw.

Response to potash application was marked upto 20 ppm. At highe potash levels, no increase in crop yield occurred. Rice, like most of the highe plants, appeared capable of building high potash content, and luxury absorptio of potash occurred at high potash levels, without further increase in growth.

(*b*) Efficiency of nitrogen absorbed by rice plant at different stages o growth was studied with T. 141, a rice variety of medium duration. Investiga tions were conducted under solution culture technique and nitrogen wa given to the crop in ten stages, at two levels, viz., 10 and 60 ppm., each stag at interval of ten days.

Efficiency of nitrogen absorbed by crop for production of grain at eac stage was measured as increase in weight of grain obtained with unit increas in absorbed nitrogen.

At low levels of nitrogen supply (10 ppm.), two stages of maximum nitroge efficiency were observed, one at the tillering stage and the second at the grain forming stage, showing that, under low nitrogen supply, rice plant needed additional nitrogen at ear development stage. At high nitrogen level (60 ppm.) however, only one stage of maximum nitrogen efficiency at tillering was obtained. Nitrogen supply at and after ear-initiation to plants grown under high manuring conditions proved harmful and pulled down grain yield considerably. At high nitrogen supply therefore, nitrogen taken up at the tillering stage was sufficient for later growth and additional supplies at ear-initiation were not needed.

At low nitrogen supply, it was seen that nitrogen taken up by plant at various stages of growth played a definite role in the development of different plant characters. During vegetative stage, nitrogen uptake resulted in increased tillering capacity of the plant. Uptake of nitrogen from ear-initiation to flowering stage resulted in increased number of grains per panicle and uptake of nitrogen from flowering to maturity increased 1000 grain weight.

(*c*) Investigations were also undertaken to study the relation between growth and nitrogen uptake of rice varieties. Four varieties of different maturation periods, viz., Ptb. 10 (110 days), Mtu. 15 (125 days), T. 141 (145 days) and BAM. 9 (155 days), were grown under field condition during the main crop season, June-December. Each variety received 30 kg/ha each of nitrogen, phosphate and potash at the time of puddling prior to planting.

Observations showed that maximum tiller number stage in all varieties is attained about 30-35 days after transplanting irrespective of the duration of the varieties. Nitrogen content of all the varieties studied, ranged from 1·7 to 2·0 per cent at the maximum tillering stage, wehreas at ear initiation stage nitrogen content varied from variety to variety and early varieties had generally higher nitrogen content than late varieties.

In early varieties (Ptb. 10 and Mtu. 15), ear-initiation followed immediately after maximum tiller number stage, whereas in the case of the longer duration varieties T. 141 and BAM. 9, there was a time lag of about 30 to 45 days respectively between the maximum tiller number stage and ear-initiation.

The process of nitrogen absorption also followed closely the pattern of growth in the two duration types. In the short duration varieties, nitrogen absorption was a continuous process. It became vigorous after establishment of plant and attained maximum value with ear-initiation and later slowed down with flowering. Vigorous uptake of nitrogen by late duration varieties occured in two stages. During early growth, nitrogen uptake was vigorous upto attainment of maximum tiller number stage. It slowed down later till ear-initiation was reached, when another stage of vigorous nitrogen absorption occured and lasted till flowering. With the attainment of flowering, there occured a nitrogen loss, probably because of flow back of nitrogen from aerial parts.

(*d*) Comparative efficiency of ammonium and nitrate nitrogen for rice crop was also investigated under solution culture. Ammonium nitrogen was given as ammonium sulphate and nitrate nitrogen as sodium nitrate. Two levels of nitrogen, 20 ppm. (moderate supply) and 100 ppm. (high supply) were tried and influence of change over of nitrogen source from ammonium to

nitrate and *vice versa* at ear-initiation stage was also studied. Data on grain yield and total nitrogen absorbed with the different treatments is given in Table XXI.

TABLE XXI

Yield and nitrogen uptake by rice plant grown under ammoniacal and nitrate nitrogen

Nitrogen source	Ammonium Nitrogen		Nitrate Nitrogen		Ammonium Nitrogen followed by Nitrate Nitrogen at ear initiation		Nitrate Nitrogen followed by Ammonium Nitrogen at ear initiation	
Nitrogen level ppm.	20	100	20	100	20	100	20	100
Dry matter gm./pot								
Ear	55	31	54	81	60	87	51	40
Total	117	80	100	163	120	182	99	88
N absorbed mg./pot	1307	2056	1207	3106	1492	3451	1312	1966

It was seen that at moderate levels of nitrogen (20 ppm.), there was no difference in grain yield between the two sources of nitrogen supply, but at high nitrogen level (100 ppm.), nitrate nitrogen was decidedly better and ammonium nitrogen proved toxic and reduced crop yield considerably and was also seen to have adverse effect on root development.

Changing over in nitrogen source at ear-initiation from ammoniacal-N to nitrate-N had beneficial effect on crop growth at both levels of nitrogen supply. Ammoniacal-N given at ear-initiation however had adverse effect on yield, crop growth and nitrogen uptake. Results showed that for rice crop, ammoniacal-N appeared suitable source of nitrogen during vegetative stage and increased tillering capacity of the plant, while nitrate-N was more beneficial at elongation and reproductive stage of plant growth.

Nitrate-N, given to the plant under solution cluture was also found to promote uptake of potassium, calcium, magnesium, manganese and phosphate by the plant.

(*e*) Utilization of ammonia and nitrate nitrogen by rice plant in relation to time of application was also studied in soil culture in pots. Ammonium and nitrate nitrogen were given as ammonium sulphate and sodium nitrate, respectively. Total nitrogen level used was 0·7 gm. N/pot and the whole quantity was either applied as full dose at different stages or growth, or given as split applications of 2/3 basal at planting, and 1/3 top dressed, either at

pre-ear-initiation stage or at boot stage. Mean grain yield per pot and percentage utilization of applied nitrogen obtained with different ammonium and nitrate nitrogen treatments is given in Table XXII.

TABLE XXII

Mean yield in gm./pot and percentage utilization of applied nitrogen

Time of fertilizer application	Yield gm./pot		Percentage of applied N absorbed	
	Ear	Straw	Total	Top-dressed
I. *Single application (Full dose)*				
A. NH_4-N :—				
1. Basal at planting	40	60	55	..
2. Pre-ear-initiation	42	51	60	..
3. At Boot stage	23	29	60	..
B. NO_3-N :—				
1. Basal at planting	16	20	4	..
2. At Pre-ear-initiation	23	29	20	..
3. At Boot stage	17	18	11	..
II. *Split application with 2/3 nitrogen basal as NH_4-N*				
A. NH_4-N top dressed :—				
1. At Pre-ear-initiation	43	58	59	75
2. At Boot stage	41	49	59	75
B. NO_3-N top dressed :—				
1. At Pre-ear-initiation	40	44	46	37
2. At Boot stage	38	41	42	25
III. *Control*	14	16	..	..

Under soil culture, ammonium-N was seen to be a far superior source of nitrogen for rice than nitrate-N, both from the point of view of nitrogen utilization and crop yield. With single application of ammonium fertilizer, about 55-60 per cent of applied nitrogen was utilised by crop as against 4-20 per cent with nitrate fertilizer. With split application also, 75 per cent of the top dressed ammonium-N was taken up as against 25-37 per cent top dressed nitrate nitrogen. Not much gain in grain yield was however obtained with split application of nitrogen, nor was there much difference in grain yield, whether nitrogen source at top dressing was ammonium or nitrate nitrogen. Straw yield however tended to be higher when ammonium nitrogen was used as top dressing.

Later application of nitrogen generally increased nitrogen content of both ear and straw and top dressing gave comparatively heavier and uniform panicles with more nitrogen content in grain.

The difference in the effect of ammonium and nitrate nitrogen under solution and soil culture, is seen to be due to non-availability of nitrogen from nitrate fertilizer for crop utilization under the submerged soil state.

(*f*) Investigations on utilization of nitrogen in relation to time of application of ammonium sulphate, under field conditions were also undertaken during the year. T. 141, a medium duration rice variety was grown during the main crop season at 0, 20, 40 and 60 kg. per hectare. The entire nitrogen dose was either given at puddling or split up, part given basal at planting and part later, after maximum tillering stage or at boot stage. Data on grain and straw yield of crop, nitrogen content are given in Table XXIII.

TABLE XXIII

Grain and straw yield and nitrogen content of rice crop

level and time of nitrogen application	Yield kg./ha.		Grain yield index	Nitrogen Per cent	
	Grain	Straw		Grain	Straw
1. Control	2493	2579	100	0·96	0·38
2. 20 kg. N/ha. basal at puddle	3052*	3603	122	0·95	0·36
3. 40 kg. N/ha. basal at puddle	2793	4195	112	0·95	0·41
4. 60 kg. N/ha. basal at puddle	2352	4066	94	1·10	0·47
5. 20 kg. at puddle + 20 kg. after maximum tillering	2330	4336	94	0·95	0·44
6. 20 kg. at puddle + 20 kg. at boot stage	2987*	3304	120	1·15	0·58
7. 40 kg. at puddle + 20 kg. after maximum tillering	1985	3998	80	1·01	0·46
8. 40 kg. at puddle + 20 kg. at boot stage	2854	4022	114	1·18	0·60
9. 20 kg. at puddle + 20 kg. after maximum tillering + 20 kg. at boot stage	2007	3694	80	1·27	0·66
C. D. at 5 per cent	454	291			

* Significant at 5 per cent level.

Significantly higher yields of grain over control were obtained only with treatments 2 and 6. Optimum grain yield in the experiment was however obtained at 20 kg./ ha. of nitrogen given basal at planting, while split application, which supplied higher nitrogen levels to the crop, gave lower yields. Split application of nitrogen, with top dressing a few days after maximum tillering stage was particularly harmful and gave grain yields even lower than the control but increased straw yield considerably. Top dressing at the boot stage generally increased number of filled grains per panicle and 1000 grain weight.

Nitrogen content in grain and straw was higher with high nitrogen levels and with split application, particularly with top dressing at the boot stage.

(*h*) Effect of application of basic slag as a carrier of P_2O_5 and SiO_2 for plant growth was studied in lowland clay soil of Mahanadi Alluvium. No significant effect on grain yield or phosphate uptake was observed with slag application but SiO_2 content of straw with slag tended to increase.

MYCOLOGY

I. *Study and estimation of resistance to disease in field of the collection of types under genetic stocks*

The reaction of the types under Genetic Stocks to diseases was studied under natural infection in the field. Observations were taken on all the types in the seedling stage, but later observations were confined to early varieties (upto 120 days duration) only. In the seedbed, 146 types were found susceptible to blast. At maturation stage seven of the early types were found susceptible to *Helminthosporiose* and one each to *Cercospora* and *Entyloma*.

II. *Helminthosporium disease*

(*i*) *Varietal susceptibility tests under artificial infection.*—Out of nearly 490 early varieties (upto 120 days duration) from Genetic Stocks taken up for study, 133 were brought forward from earlier tests. These 133 varieties were tested during the year under two artificial infection tests, and 109 varieties were classified as susceptible. The remaining 24 varieties, which behaved as resistant in all the tests so far, will be carried forward for further tests next year.

(ii) *Co-ordinated varietal trial in States.*—The co-ordinated trial of five varieties, Ch. 13, Ch. 45, T. 141, T. 498-2A and BAM. 10, selected as resistant to Helminthosporium disease, was continued for the 4th year in succession in 40 research centres in the states of Uttar Pradesh, Bihar, West Bengal, Assam, Orissa, Andhra, Madras, Mysore and Kerala. The trial was carried out in collaboration with the State Departments of Agriculture. Along with these five varieties, a standard susceptible strain, *Benibhog*, sent from Central Rice Research Institute and one or two local susceptible strains of the respective states were included in the tests. Observations on disease incidence were recorded on samples collected at three stages, i.e., seedling stage, post-transplanting stage (one month after transplanting) and pre-harvest stage.

In some of the centres the disease did not appear. In others where the disease occured, the varieties, Ch. 13, Ch. 45, T. 141 and BAM. 10 behaved as resistant to moderately resistant. The varieties T. 498-2A did not behave as uniformly resistant in all centres.

(iii) *Breeding for disease resistance.*—In co-operation with the Botany Division a hybridization project has been undertaken to evolve varieties resistant to both Helminthosporium and blast diseases of rice. Crosses were made in 1955-56 between the variety BAM. 10, resistant to Helminthosporium but susceptible to Blast and Co. 25, resistant to blast but susceptible to Helminthosporium. During the present year, the F_2 progenies were studied under field conditions and promising selections were carried forward for further tests.

III. *Blast Disease*

(i) *Varietal susceptibility tests under artificial infection.*—Out of 490 early duration types (maturing with 120 days) available in the Genetic Stock collection, 195 types have been found susceptible in studies carried out in earlier years. During this year one hundred and fortysix types under genetic stock were found susceptible to blast in the seed bed.

(ii) *Co-ordinated varietal trial in States.*—The co-ordinated trial of 14 varieties selected as resistant and moderately resistant to blast was continued in 40 research centres all over the country. The test varieties continued to behave as relatively resistant in all centres except in Ponnampet, Nagenahalli, Mahabaleswar, Kanke, and Agartala which are situated at an altitude of 2,000 to 4,000 ft. In these stations they were mostly moderately susceptible to susceptible. The variety S. 67, a strain released from Mysore State, however, behaved as relatively resistant in all these centres.

(iii) *International Co-operative blast resistant trial.*—In pursuance of a recommendation made by the F. A. O. Working Party on Rice Breeding at its 6th Meeting held in Malaya in 1955, a co-ordinated blast varietal resistance trial was started in many rice growing countries. Under this project varieties reported as resistant to blast from the different rice growing countries as well as some susceptible types were listed and distributed to testing centres in Japan, India, Philippines, Taiwan, U. S. A. and Egypt. At Cuttack, 35 varieties resistant and 12 susceptible to blast received from Japan, Egypt, Indonesia, Malaya, Philippines, Taiwan and U. S. A. were tested along with 8 resistant and 2 susceptible Indian varieties. The varieties were tested under artificial infection in the seedling stage and under natural infection in the field. The standard procedure for testing and evaluating the reaction of the varieties evolved at this Institute was followed. The field tests were carried out twice during the year, once in the main season (June-July to November-December) and again in the 2nd crop season (December-January to April-May).

Egyptian, Japanese, and the U. S. A. varieties did not fare well in the main crop season. They were severely attacked by thrips in the seedling stage and by a few other pests at the time of flowering. All the others grew normally with a number of tillers. In the second crop season, there was an excellent stand of all the varieties, including the Egyptian and the Japanese and those from the States and Taiwan.

There was heavy incidence of blast on Co. 13, the highly susceptible variety used for flanking the field experiments. Of the 12 susceptible varieties used in the first crop season, 7 were found susceptible, one moderately susceptible, two moderately resistant and two resistant. The two resistant varieties were Calora and Fortuna of U. S. A., which as mentioned earlier had suffered a set back in growth ; besides they were found susceptible in the second crop season as mentioned below.

In the second crop season, five out of the six susceptible varieties included were found to be susceptible including the two varieties from the States. *Nabatat Asmer* from Egypt which was moderately resistant in the first crop tests, was found to be resistant under conditions favourable for blast development in the season.

The 31 resistant varieties tested in the first season included 8 from Indonesia, whose reaction to blast in that country was not definitely known. Of these 31 varieties, 19 were resistant, 5 moderately resistant, 4 moderately susceptible and 3 susceptible. In the second crop season, amongst 20 varieties tested, 9 were found to be resistant, one moderately resistant and five each were moderately susceptible and susceptible, respectively. The classification of the varieties is given in Table XXIV.

Table XXIV

Reaction of the varieties included in the first crop season based upon artificial infection in seedling stage, and field reaction in post-transplanting (leaf blast) and in flowering stages (neck infection)			Reaction of rice varieties included in second crop season (January-April) based upon field reaction in post-transplanting stage (leaf blast only)		
Serial No.	Name of variety	Reaction at Cuttack	Name of variety		Reaction at Cuttack
(1)	(2)	(3)	(4)		(5)
		A. *Resistant Types*			
1.	Nahada	(Egypt) M.R.			
2.	Agami-Mont	" R	Agami-Mont	(Egypt)	R
3.	Giza-14	" M.S.	Giza-14	"	M.S.
4.	Co. 4	(India) R	Shikare-Shiroke	(Japan)	M.R.
5.	Co. 26	" R	Fujisaka. 5	"	S
6.	B. J. 1	" R	Norin-17	"	R
7.	SM. 6	" R	Norin-22	"	R
8.	SM. 8	" R	Kanto-51	"	S
9.	S-67	" R	Sensho	"	M.S.
10.	AKP. 8	" M.R.	PI-1	"	R
11.	AKP. 9	" M.R.	Rei-Shi-Ko	"	S

TABLE XXIV—*contd.*

Reaction of the varieties included in the first crop season based upon artificial infection in seedling stage, and field reaction in post-transplanting (leaf blast) and in flowering stages (neck infection)			Reaction of rice varities inculuded in second crop season (January-April) based upon field reaction in post-transplanting stage (leaf blast only)		
Serial No.	Name of variety	Reaction at Cuttack	Name of variety		Reaction Cuttack
(1)	(2)	(3)	(4)		(5)
		A. *Resistant Types*			
12.	Peta (Indonesia)	M.S.	To-To	(Japan)	S
13.	Intan „	M.S.	Kwang-Fu-I	(Taiwan)	R
14.	Salak „	S	Chia-Nong-Yo 242	„	S
15.	Tjahaja „	S	Chia-Nong-Yo 280	„	R
16.	Sigadis „	R			
17.	Remadja „	M.S.			
18.	Tjina „	S			
19.	Bengawan „	R			
20.	Milek-Kuning (Malaya)	R			
21.	Kontor „	M.R.			
22.	Seri Raja „	R			
23.	Mayang-Sagumpal „	R			

24. Wag-Wag	(Philippines)	R			
25. Raminad Strain 3	,,	R			
26. Zenith	(U.S.A.)	R	Zenith	(U.S.A.)	R
27. Lacross	,,	R	Lacross	,,	M.S.
28. C. I. 9045	,,	R	C. I. 9045	,,	R
29. C. I. 9075	,,	R	C. I. 9075	,,	M.S.
30. C. I. 9155	,,	M.R.	C. I. 9155	,,	R
31. C. I. 9249	,,	R	C. I. 9249	,,	M.S.
		B. *Susceptible Types*			
1. Nabatat-Asmer	(Egypt)	M.R.	Nabatat-Asmer	(Egypt)	R
2. Sabaini	,,	S	Co. 13	(India)	S
3. Co. 13	(India)	S	Norin-1	(Japan)	S
4. ADT-10	,,	S	Kunshan-Wa-Shiang-Ken	(Taiwan)	S
5. MAS	(Indonesia)	S			
6. Nachin-11	(Malaya)	S			
7. Siam-29	,,	M.S.			
8. Serendah-Kuning	,,	M.R.			
9. Buenketan	(Philippines)	S			
10. Thailand	,,	S			
11. Caloro	(U.S.A.)	R	Caloro	(U.S.A.)	S
12. Fortuna	,,	R	Fortuna	,,	S

NOTE :— R=Resistant ; M.R.=Moderately Resistant, S=Susceptible ; M.S.=Moderately Susceptible.

The classification of varieties given in Table XXIV is based upon the first year's trials, and it is necessary to confirm the resistant reaction of the varieties before definite conclusions can be reached. In general, it may be said that most of the varieties reported as resistant continued to be resistant in Cuttack. Similarly the susceptible varieties were found to be susceptible.

(iv) *Breeding resistant varieties by hybridization.*—This project for evolving high yielding blast resistant strains has been undertaken in co-operation with the Botany Division. F_3, F_4, F_5 and F_6 progenies of crosses between Co. 13, a short duration variety, very susceptible to blast and Co. 25 a long duration variety resistant to blast were studied under high fertility conditions. Promising single plant selections based on early to medium maturity, good yield and resistance to blast have been made for further study.

(v) *Control of blast by spraying and dusting.*—(*a*) *Efficiency of fungicides used as sprays.*—In a spraying trial to control blast, 4 fungicides i.e., Bordeaux Mixture 1 per cent, Fungi Copper Geigy 0·5 per cent, Copper Sandoz 0·5 per cent and Fernide 0·5 per cent were used. Co. 13, a short duration variety, very susceptible to blast was planted late on 8-8-1956 and manured with 40 lbs. N per acre as Ammonium sulphate. The layout was a randomised block with 8 replications, the size of unit plot was 29 ft. × 9·75 ft. Though 4 sprayings, 2 for controlling leaf infection and 2 for neck infection were contemplated, only two sprayings one at leaf stage and one after flowering were actually given.

Observations on neck infection were taken at the time of hervest. From each unit plot, four random samples of 1·5 ft. × 1·5 ft. containing 6 plants per sample were taken and percentage of tillers with neck infection was determined. Yields of unit plots were recorded.

Analysis of the data showed that percentage of neck infection in plots sprayed with Bordeaux Mixture, Fungi Copper Geigy, and Copper Sandoz was lower than in control, but the difference between Copper Sandoz and control was not statistically significant. Bordeaux Mixture, Fungi Copper Geigy and Copper Sandoz were also associated with significantly higher yield than control. The yield and neck infection data are given in the Table below.

TABLE XXV

	Bordeaux mixture	Fungi Copper Geigy	Copper Sandoz	Fernide	Control	C. D. (0·05)
Yield per acre in lb.	1205	1226	1275	990	992	156
Percentage of Neck infection (Angular values)	3·43 (10·19)	2·33 (7·26)	5·42 (12·49)	8·30 (15·63)	8·73 (15·84)	(4·60)

(*b*) *Efficiency of low volume spraying.*—The efficiencies of low volume spraying at 20 gallons of spray fluid per acre and normal volume spraying at 100 gallons per acre for control of blast were compared in a trial. Co. 13, a short duration variety, very susceptible to blast was planted late (6-8-1956) and manured with 40 lb. N per acre as Ammonium sulphate. The layout was a randomised block with 9 replications, the size of unit plot being 93 ft. × 11·25 ft. only. Only two sprayings were given as the disease incidence was low.

Observations on neck infection were taken at harvest by suitable sampling. Each unit plot was divided lengthwise into 3 strata of equal size. Two random samples of 2·5 ft. × 2·25 ft. were taken from each stratum, each sample containing 15 plants. Percentage of neck infected tillers was determined. Yields of individual plots were recorded. The data are given in Table below.

TABLE XXVI

	Normal volume	Low volume	Control	S. E.	C. D. (0·05)
Yield per acre in lb.	1636	1418	1336	24·7	74
Percentage of neck infection (Angular values)	3·01 (9·55)	4·14 (11·34)	10·16 (18·43)	(0·71)	(1·60)

Analysis of the data showed that both Normal volume and low volume sprayings were associated with significantly lower infection and higher yield than the control. During this year, however, there was significantly lower neck infection and higher yield in normal volume over low volume treatments.

(c) *Efficiency of fungicides used as dusts.* The efficiency of dusting rice with Agrosan GN., and Ceresan slaked lime in reducing blast incidence was investigated using Bordeaux 5 : 5 : 50 as a standard fungicide. The layout was a randomised block with 6 replications, the size of unit plot being 128 ft. × 14·25 ft. Co. 13, a short duration variety, susceptible to blast was grown. Planting was done late (on 9-8-1956) and Ammonium sulphate at 40 lb. per acre was applied about 25 days after planting. As the disease was not severe the fungicides were applied only once, *i.e.*, at the leaf infection stage, about 40 days after transplanting.

Observations on neck infection were taken at harvest on sampling basis. For sampling, 3 rows from all sides of a unit plot were removed. The rest of the plot was divided into 3 equal strata along the length and 2 random samples, 2·5 ft. × 2·25 ft., each containing 15 plants per sample were taken. Percentage of neck infected tillers was determined. The Yields of individual plots were recorded.

The incidence of "neck" blast was only 2·35 percent in the control plots and therefore though on an average there was silghtly less infection in the plots treated with mercurial dusts, the differences were not statistically significant. As regards the yield, however, all the fungicidal treatments, including Bordeaux were associated with significantly higher yield than the control. The yield data are given in Table XXVII.

TABLE XXVII

——	Agrosan	Ceresan	Bordeaux	Control	C.D. (0·05)
Yield in lb. per acre	1461	1391	1333	1214	27·16

IV. *Seed treatment experiment*

A seed treatment experiment was carried out in the second crop season (December to April) with 11 fungicides, *i.e.*, Agrosan G. N, Special Agrosan, Fernasan A., Y. F. 2776, Yellow Cuprocide, Landisan, Harvesan, Abavit B, Ceresan, Fungi Copper, andCopper Sandoz. Two short duration varieties, Ch. 45 and Benibhog, resistant and susceptible to Helminthosporium disease respectively, were used.

Seeds were treated with 1 : 400 by weight of the fungicides and sown broadcast in a split plot layout with varieties as the main split and treatments as the second split in 4 replications. The unit plot size was 14·5 ft. × 9·5 ft.

Observations on germination and seedling blight and leaf spot due to Helminthosporium disease were recorded a fortnight after sowing on five samples per plot of 6 inches square each. Yields of individual plots were recorded. There was very little disease at post germination stage. There was no difference as regards germination and yields between the treatments and the control.

V. *Control of diseases and pests in second crop*

An experiment was carried out in the second crop season (December-April) to see to what extent plant protection measures would contribute to increased yields in this season. Six varieties of rice some of which were resistant and some susceptible to blast, helminthosporium disease or stem borer were included. Seeds were treated with Agrosan G. N., and the seedlings were dipped in a combined solution of Coppesan 0·5 percent and Folidol 4·5 cc. per gallon of water at the time of transplanting and a combined spraying of Coppesan and Folidol at the same dose was given about a month after transplanting.

The crop under protection gave a significantly higher yield than control. Of the varieties used, the performance of Ch. 45 was the best.

ENTOMOLOGY

A. Field Pests

I. *Varietal susceptibility investigations.*

(*a*) *Gall fly :* [*Pachydiplosis oryzae* (W. M.) Mani.]

It was noted in previous years that the infestation by the gall fly was relatively lower in the varieties with pigmented foliage and in those with low tillering habit. With a view to correlate the infestation with pigment in different vegetative parts of the plants, nearly five hundred plants in the F_4 generation of the cross between CP. 12 (purple) and Ch. 3 (green), with varying degrees of pigmentation in leaf blade and leaf sheath, were studied. About two hundred plants with different grades of pigmentation in the leaf blade and leaf sheath with varying degrees of infestation were selected for further studies.

(*b*) *Stem borers :* [*Schoenobius incertulas.* Wlk., *Scirpophaga innotata* Wlk., *Sesamia inferens* Wlk., *Chilo simplex* Butl. and *Chilotraea* (*Proceras*) *polychrysa* Meyr.]

One hundred and fifty *dalua* varieties were studied at the seedling and flowering stages to determine their reactions to stem borers. The percentage infestation at the seedling stage (dead hearts) ranged from 4·34 in the variety Ptb. 31 to 62·85 in the variety Ch. 41. The percentage of infestation at the flowering stage (white earheads) ranged from 0·0 in the varieties T. 2048, T. 1655 and T. 657 to 50·0 in the variety HR. 21.

It was found that the varieties which showed dead hearts at the seedling stage did not show the same degree of infestation at the flowering stage. Hence, while assessing the varietal susceptibility, the reactions at both the stages will have to be taken into account.

II. *Incidence of pests in relation to agronomic practices*

Studies on the seasonal abundance of pests were continued with the object of determining the factors favourable for the prevalence and abundance of pests and the relationship between the incidence of pests and the season, time of planting and the age of the crop.

In this experiment, 30 days old seedlings of two varieties, viz., CH. 45 and DI. 4, were planted at fortnightly intervals from the middle of July till the end of March. The pest infestation was estimated by examination of samples drawn from each planting when the crop was 60 and 90 days old and at harvest. The results obtained this year are discussed below.

(a) *Gall fly.*—The infestation commenced by the last week of July in the nursery (5·8 percent) and continued till the beginning of February (0·75 percent in the 90 days old crop). The peak period of infestation was between the middle of September and the middle of October, during which the percentage of gall fly attacked tillers was 46·48 and 56·05 in the 60 and 90 days old crops respectively. The infestation was more in the crop at 90 days age than at 60 days, irrespective of the date of transplanting. In general, plantings done from the middle of August to the middle of September were severely affected. The highest percentage of natural parasitization of gall fly grubs was 81·05 from the middle of October till the middle of November.

Counts of flies at the light-traps showed that from August, there was a steady increase in the number till the end of September after which there was a slight decrease. During the middle of October there was again an increase in the population which declined from the last week of November.

(b) *Stem borers.*—Stem borer moths were prevalent in the fields from early August till the middle of April. The infestation was 0·24 percent in early October and it reached a maximum of 61·42 percent during the last week of February. Plantings done in December suffered severe infestation at the heading stage while plantings done in January recorded highest percentage of dead hearts.

Catches of moths at the light-traps showed that a brood emerged in early October. There was a steady rise in the population of the moths from the beginning of December and the peak was during the third week of January to the middle of February. There was a second peak in the last week of March.

The early brood in October infested the standing crop causing 17·4 percent dead hearts. The moths which emerged in the last week of January infested the standing crop resulting in 61·42 per cent dead hearts in the dalua crop which was in the tillering phase and the moths which emerged during March infested the crop planted in December and January resulting in 21·88 percent white earheads.

III. *Insecticidal trials to control pests*

(i) *Efficacy of different methods of application of insecticides in the control of rice pests.* (a) *Gall fly.*—An experiment was conducted to determine the most effective and economic method of application of parathion (Folidol—E 605.) to control gall fly. The variety used was GEB 24. There were six treatments as given in the Table. The sprayings were discontinued a fortnight before flowering in the treatment with regular sprayings. The degree of pest infestation in the different treatments was estimated by drawing random samples during the last week of October *i.e.* a few days before flowering. The results are tabulated in the Table XXVIII on page 48.

Table XXVIII

Control of Gall fly with Folidol E-605 EC

Treatments	Mean Number of tillers per unit sampling area of 2′×2′	Mean Number of Gall fly attacked tillers per unit sampling area of 2′×2′	Mean percentage of gall fly attacked tillers	Mean percentage of big tillers (angular values within brackets)	Yield		Mean weight of 1,000 grains in grammes
					in pounds per acre	Per cent increase over check	
T_1 Check	414·19	200·66	46·99	18·27 (24·58)	2115·10	..	17·972
T_3 Nursery Irrigated twice with 0·1 percent solution of Folidol E 605 EC.	428·69	201·66	47·47	15·50 (22·65)	2142·84	1·31	18·107
T_3 Nursery Irrigated and spraying the transplanted crop thrice with 0·08 percent Folidol according to the prevalance of Gall fly.	349·78	183·41	52·24	21·03 (27·02)	2550·23	20·57	18·231
T_4 Spraying the nursery twice with 0·08 percent Folidol and spraying the transplanted crop thrice with 0·08 percent Folidol according to the prevalence of Gall fly.	369·56	187·72	50·45	21·08 (26·79)	2623·69	24·05	18·152
T_5 Spraying the nursery twice with 0·08 percent Folidol and spraying the transplanted crop with 0·08 percent Folidol at regular intervals of 10 days (8 sprayings).	260·53	125·41	46·71	35·95 (36·33)	2955·06	39·71	18·488
T_6' Spraying the transplanted crop thrice with 0·08 percent Folidol according to the prevalance of gall fly.	382·66	206·28	54·41	20·67 (26·34)	2275·75	7·60	18·115
C. D. (0·05)	70·72	54·72	9·79	10·25 (6·019)	262·31	..	0·122

It may be seen from the table that there was no significant difference in the percentage infestation between the treatments, but there were differences both in the total number of tillers and in the number of gall fly attacked tillers per unit sampling area. The mean number of tillers in the sprayed treatments (T_3, T_4, T_5 and T_6) was less than in the unsprayed treatments (T_1 and T_2). The percentage of big tillers is more in the sprayed than in the unsprayed treatments. The treatment with eight sprayings (T_5) had recorded the highest yield as compared to the treatments with three sprayings (T_3, T_4 and T_6).

Though on percentage basis there was no significant difference in the infestation between the treatments, yet the number of gall fly attacked tillers per unit sampling area was less in the sprayed treatments (T_3, T_4, T_5 and T_6) than in the unsprayed (T_1 and T_2). The sprayings were discontinued a fortnight before flowering and the subsequent infestation in the late formed subsidiary tillers was not checked which increased the percentage infestation. But the percentage of "big" tillers was more in the sprayed treatments than in the unsprayed. The mean weight of 1000 grains was higher in the sprayed treatments than in the unsprayed, which resulted in the increase in yield in the sprayed treatments.

IV. *Influence of fertilizers on the incidence of stem borers*

With a view to confirm the results obtained in the previous year in this study, the experiment was repeated. The results are given in the table XXIX below.

It might be seen from the table that although the number of egg-masses per unit sampling area was relatively more in the treatments with high levels of nitrogen, yet there was no significant difference in the number of egg-masses per tiller between the treatments. In the nitrogen treated plots the number of tillers per plant was relatively more and consequently the leaf area available for oviposition was also more.

The percentage of borer attacked tillers in the seedling stage in the manured treatments was less than in the unmanured, but there was no significant difference within the different manurial treatments. The inter-treatment correlation between the number of tillers and the percentage of borer attacked tillers in the seedling stage was negative and the correlation coefficient $r=-0{\cdot}7444\pm0{\cdot}2230$. From the observations made on the micro-climatic factors prevailing at the base of the culms, it was seen that they play some part in bringing about this difference.

The percentage of white earheads was significantly more in all the treatments with nitrogenous fertilizers while there was no significant different between the check and the treatment with phosphatic fertilizer alone. There was a significant positive correlation between the number of earheads and the percentage of white earheads, and the correlation coefficient $r=0{\cdot}8805\pm0{\cdot}1124$.

A significant negative correlation is observed between the percentage of borer attacked tillers at the seedling stage and the percentage of white earheads at the time of harvest and the correlation coefficient $r=-0{\cdot}8361\pm0{\cdot}151$. The percentage of white earheads was correspondingly more in the treatments with high levels of nitrogen. By controlling this high infestation at the earhead stage of the crop, the yield potential of manured treatments could be effectively raised.

Table XXIX

Influence of fertilizers on the Incidence of stem borers

Treatments	Mean number of egg-masses per unit sampling area of 1·5′×1·5′ Angular values	Mean number of egg-masses per tiller Angular values	Mean number of tillers per unit sampling area of 1·5′×1·5′	Percentage of borer attacked tillers in the seedling stage (Angular values within brackets)	Mean number of earheads per unit sampling area of 1·5′×1·5′	Percentage of white earhead at harvest (Angular values within brackets)	Yield	
							In pounds per acre	Per cent increase over check
T_1 Check	0·7930	0·7158	12·57	22·61 (27·63)	24·76	11·56 (19·83)	867·40	—
T_2 *Japanese method*	0·9017	0·7163	25·74	19·58 (26·02)	46·21	25·73 (30·39)	1805·06	108·10
Basal dose (before transplanting								
Green leaves providing 30 N/A.								
Compost providing 25 N/A.								
Ammonium sulphate providing 20 N/A.								
Super phosphate providing 36 P_2O_5/A.								
Top dressing (one month after Transplanting).								
Ammonium sulphate providing 20 N/A.								
T_3 *Basal dose* (before transplanting)	0·9336	0·7164	28·97	14·06 (21·69)	45·57	32·82 (34·86)	1789·68	106·33
Ammonium sulphate providing 95 N/A.								
Super phosphate providing 36 P_2O_5/A								
T_4 *Basal dose* (before transplanting)	0·8797	0·7154	24·22	17·73 (24·75)	45·94	24·74 (31·72)	1690·12	94·85
Ammonium sulphate providing 95 N/A.								
T_5 *Basal dose* (before transplanting)	0·8020	0·7116	24·69	19·16 (25·73)	51·96	24·74 (29·69)	1746·21	101·32
Ammonium sulphate providing 75 N/A.								
Top dressing (one month after transplanting).								
Ammonium sulphate providing 20 N/A.								
T_6 *Basal dose* (before transplanting)	0·8315	0·7181	12·82	19·41 (26·12)	26·74	13·31 (21·26)	951·23	9·66
Super phosphate providing 36 P_2O_5/A.								
C. D. (0·05)	0·0918	0·0074	3·976	8·82 (6·012)	6·55	5·47 (3·62)	288·52	—

V. *Estimation of loss in yield due to stem borers*

Investigations were carried out to estimate the loss caused by stem borers at seedling stage and flag leaf stage. The treatments consisted of spraying the crop with parathion 0·1 per cent to check infestation at the seedling stage or at the flag leaf stage or at both the seedling stage and flag leaf stage. The results are given in table XXX below.

TABLE XXX

Estimation of loss due to stem borers

Treatments	Borer infestation percentages				Yield in lb./acre	Percentage loss in yield due to borer infestation	
	Dead hearts	Reduction over check	White ear heads	Reduction over check.			
Crop unsprayed or check-C.	12·89	—	25·15	—	1201·14	Cumulative loss E+L—C.	44·15
Crop sprayed in the seedling stage—E.	3·74	70·98	25·32	—	1570·28	Flag leaf stage E+L—E.	26·99
Crop sprayed in the flag leaf stage-L.	12·26	4·11	19·64	21·90	1686·85	Seedling stage E+L—L	21·57
Crop sprayed in both the stages as E and L above. E+L.	4·58	64·46	17·08	32·08	2150·84		

It might be seen from the table that the loss in yield due to stem borer at the early stage was 21·57 per cent and at the flag leaf stage was 26·99 per cent. The cumulative loss sustained by the crop was 44·15 per cent.

VI. *Plant protection experiment*

An experiment was conducted to determine the efficiency of the recommended plant protection measures, *viz.*, seed treatment with mercurial fungicides and spraying the crop against diseases and pests. The treatments consisted of seed treatment with special Agrosan and spraying the seed beds and the transplanted crop with a mixed solution of Parathion 0·1 per cent (Folidol-E. 605) and Copesan 0·5 per cent, thrice according to the prevalence of stem borers and diseases. In the variety Ch. 45, the adoption of the above measures resulted in an increase in yield of 39·51 per cent over the check.

VII. *Occurrence and control of other field pests*

Thrips oryzae Will., *Nephotettix bipunctatus* Fab., *Nephotettix apicalis* Mots., and *Nilaparvata sordescens* Linn., infested the standing crops during September and October. These were effectively controlled by spraying Parathion 0·04 per cent (Folidol-E. 605) or Chlorinated hydrocarbon 0·04 per cent (Endrin).

B. *Pests of Stored Grain.*

Efficacy of prefabricated Aluminium Bin for bulk storage of paddy.—It was indicated in the previous year that the prefabricated Aluminium bin may be good for the storage of food grains as the infestation by pests was much less in aluminium bin than in the wooden bin while it may not be suitable for seed storage as the viability was completely lost within twelve months of storage. This experiment was repeated for confirming the above results.

Three hundred maunds of unhusked rice were stored in each bin for a period of twelve months, from March, 1956 to February, 1957. The temperature of grain inside the bins and the range of atmospheric temperature and humidity were recorded fortnightly. The running infestation, percentage of weevilled grain and the moisture content of the grain were determined from samples drawn every month. The percentage of viability was recorded thrice *viz.*, at the commencement of the experiment, six months after and at the termination of the experiment.

It was found that the population of *Sitotroga cerealella* Oliv. was practically nil in the Aluminium bin while it was very high in the top layers of the wooden bin.

The mean percentage of weevilled grains was 2·37 and 5·00 in the Aluminium and wooden bins respectively. The loss in storage due to insects was 0·8 per cent and 2·2 per cent in the Aluminium and wooden bins respectively. There was no significant difference in the milling quality as determined by the whole grain rice and broken rice, obtained from the grain stored in the two bins.

The mean percentage of viability was 39·25 and 52·50 after six months of the storage and 0·00 and 37·35 after twelve months of storage in the aluminium and wooden bins respectively. The loss in viability observed in the aluminium bin may be attributed to the fact that the temperature of the grain inside the bin was generally higher by about 2·0°C than that of the grain in the wooden bin. Further, due to total lack of ventilation, there was considerable sweating of the grain resulting in higher moisture condensation and localized 'hot spots' in the aluminium bin. Hence, the aluminium bin may not be suitable for seed storage unless it is improved upon for aeration of the grain.

STATISTICS

Besides helping the various Research Divisions in the design of experiments and interpretation of results, the following investigations were carried out :—

I. *Border effect*

To determine the effect of border rows on yield and on yield attributes, namely, number of ear heads, length of ear heads and height of plant at harvest, four medium duration varieties were planted with three spacings, 6 in. × 6 in.,

9 in.×9 in. and 12 in.×9 in. data on yield and plant characters were collected separately ring by ring upto the third ring and rest of the rings were clubbed together as one unit. The data obtained are summarised in Table XXXI.

TABLE XXXI

Average yield and other plant attributes for different rings and spacings.

Spacing in in.×inc.	Mean yield in lb. per acre.			
	Outermost ring	Second ring	Third ring	Central portion
6×6	2666	1424	1189	1067
9×9	2130	1324	1281	1220
9×12	2235	1559	1590	1538
	Mean number of effective ear-heads per plant.			
6×6	6·85	3·53	3·07	2·86
9×9	9·84	6·81	6·44	6·16
9×12	13·06	9·28	9·00	9·19
	Mean ear-head length in cm.			
6×6	17·56	16·45	16·33	16·71
9×9	17·98	17·51	17·59	17·06
9×12	18·27	18·31	17·86	17·86
	Mean height per plant in cm.			
6×6	96·21	89·77	91·71	89·12
9×9	99·52	100·24	99·23	97·46
9×12	104·47	106·17	104·88	103·60

It was observed that percentage increase due to outermost ring over the central portion was 84, 63, 4 and 3 respectively for yield, number of ear heads, length of ear head and height of plant. The outermost ring yielded significantly higher than the subsequent rings in all the spacings. But in case of 6 in.×6 in. spacing, it was observed that the second ring also yielded significantly higher than the rest after which no significant differences were noticed. From the above data it may be concluded that nearly one foot border all round the plot may be necessary to avoid the marginal effects on plot yields.

It may also be seen from the data presented above that number of effective ear heads is more in border rows than the central portion whereas length of ear head and height of plant are not much influenced by the border rows. The above results indicate that the increased yield in border rows apparently was due to the production of more tillers than in central rows.

II. *Estimation of Yield by sampling for ratio of grain to total produce*

Investigations were carried out to study the comparative efficiency of direct sampling and sampling for ratio of grain weight to total produce for estimating yield. Sampling units of 3 ft.×3 ft., 4½ ft.×4½ ft. and 6ft.×6 ft. were utilized. It was found during this year that sampling variance for ratio method was higher than that for the direct method in case of all the three sampling units ; during the last year sampling variance for the ratio method was found to be less than that for the direct estimate. This difference may be due to the poor and uneven stand of the crop during the current year.

III. *Sampling for pollen sterility*

Multistage sampling was adopted to determine the pollen sterility in some *japonica*×*indica* hybrids, the different stages of sampling being plants, ear heads within plants and spikelets within ear heads. The complements of variation for each of three stages were calculated. The number of plants needed to attain 2 per cent and 4 per cent standard error of mean with different combinations of ear heads and spikelets have been worked out and given in Table XXXII.

TABLE XXXII

Number of plants required to obtain a 2 per cent and 4 per cent of mean pollen sterility for varying intensity of sampling

Number of ear-heads	Number of plants spikelets	Number of plants required to give 2 per cent S. E. of mean	Number of plants required to give 4 per cent S. E. of mean
2	1	36	9
	2	23	6
	3	20	5
	4	18	4
3	1	28	7
	2	20	5
	3	17	4
	4	15	4
4	1	24	6
	2	17	4
	3	15	4
	4	14	4

It was found that to get a standard error of 4 per cent of mean, it would be necessary to examine about 6 plants and 2 ear heads in each plant and 2 spikelets in each ear head.

IV. *Correlation Studies*

In a varietal-*cum*-dates of planting experiment conducted during the second crop season the simple correlation coefficients between yield, number of ear heads, length of ear head, number of grains per ear head and height of plant at harvest were calculated for each variety under different dates of planting separately and the results are presented in Table XXXIII.

TABLE XXXIII

Simple correlation coefficients between yield and its attributes.

Variety	Dates of planting	Correlation between yield and			
		No. of ear heads	Mean ear length	Mean no. of grain per ear	Height at harvest
PTB-10	D_1	·7923	·4293	·3431	·4878
	D_2	·8990	·4495	·5071	·3441
	D_3	·9171	·5916	·4400	·5279
	D_4	·7781	·5949	·5371	·4451
	Mean	·8668	·5227	·5370	·4777
CH-62	D_1	·8887	·3289	·7482	·5170
	D_2	·9310	·4269	·7337	·3735
	D_3	·9238	·2413	·4839	·3608
	D_4	·8490	·2822	·3973	·5347
	Mean	·9033	·3185	·6044	·4462
CH-63	D_1	·9625	·2615	·7988	·5097
	D_2	·8990	—·0291	·4041	·6416
	D_3	·9411	·5340	·8053	·2522
	D_4	·9203	·0322	·6132	·2327
	Mean	·9329	·2660	·6858	·4136
MTU-15	D_1	·9440	·3429	·7091	·4544
	D_2	·9306	·2629	·3578	—·0320
	D_3	·9335	·6294	·7278	·5273
	D_4	·9075	·5857	·6449	·5658
	Mean	·9289	·4699	·6291	·4053
CB-1	D_1	·9205	·1174	·2520	·0182
	D_2	·9208	·1079	·2079	·1529
	D_3	·8594	·4665	·5272	·3309
	D_4	·9667	·6395	·5499	·0653
	Mean	·9246	·3627	·4219	·1489
Tepa-1	D_1	·9196	·4278	·6559	·5055
	D_2	·8909	·0520	·4656	·1627
	D_3	·9250	·5791	·6834	·3027
	D_4	·9637	·2888	·4754	·0909
	Mean	·9302	·3540	·5784	·2729

D_1=5-12-56 D_2=23-12-56 D_3=11-1-57 D_4=29-1-57.

It will be seen from the above table that significant correlations were observed between yield and number of ear heads in all the varieties planted on different dates whereas other correlations were not significant in all the cases. The magnitude of correlations was different for different pairs of characters. Yield per plant shows highest association with number of ear heads followed closely by number of grains per ear head and length of ear heads and least with plant height.

The homogeneity of correlations was tested and it was found that there was no significant differences in coefficient of correlation between dates of planting in any pair of characters. Among different varieties significant differences between correlation was observed in case of yield and mean ear length. Correlation between other pairs of characters indicate no heterogeneity among varieties.

The results thus obtained show that from amongst the four characters studied the greatest contribution to yield is made by number of ear heads followed in order by number of grains per ear, length of ear head and height. Correlations of different characters with yield do not seem to be influenced by environmental changes as provided by different dates of planting.

Farm

I. *Multiplication of improved strains*

A total quantity of 2,169 mds. of seed of the most popular strains of Orissa state was produced during the year.

II. *Maximum potential experiment*

This is a permanent experiment now in progress for 8 years on the same site, a block of 4·93 acres, to see how far yields could be stepped up by adopting the improved methods of cultivation. A green manure crop of *Daincha* was grown *in situ* (estimated to give 4,000 lb. of green matter) and buried in the soil a week before the planting. Fifty lb. of Super phosphate per acre was added to the soil at planting. The strain T. 1242 was planted in the second and third week of August 1956. The yield obtained was only 1622 lb. per acre this year. This low yield was due to very unfavourable weather conditions.

III. *Comparative efficiency of sowing practices,* viz.,

1. Transplanting on 27th July, 1956,
2. Transplanting on 27th August, 1956, and
3. Dibble sowing in puddle on 27th July, 1956.

In the previous two years "Dibble sowing" in the third week of June under optimum moisture conditions (a practice prevalent with the cultivators) was one of the three treatments but this treatment could not be included in

his experiment this year as the conditions were not favourable for sowing nd so in its place a treatment, namely, transplanting on 27th August 1956, vas substituted.

The results of the trial indicate that the dibble sown crop of T. 141 in puddle gave an yield as good as that of the planted crop on 27th July and 27th August, while the dibble sown crop of T. 1242 in puddle gave lower yield by about 25 per cent as compared with the planted crop on 27th July but gave an increased yield of about 10 per cent as compared with the crop planted on 27th August.

It would be seen from the data that the yield of the late planted (*i.e.*, 27th August) crop of T. 141 was as good as that of the early planted (*i.e.*, 27th July) crop of T. 1242 and so the strain T. 141 is best suited for late planting. The particulars of the experiment are given in Statement I.

IV. *The efficiency of different intercultural practices*, viz.,

1. Working Japanese weeder,
2. Country plough,
3. Hand weeding, and
4. No weeding as control.

The results of the trial indicated that there was no difference in yield between the different treatments, and this is in conformity with the previous years finding. This experiment was carried out in a low-land with Strain T. 1242.

V. *The Effect of planting on different dates on yield*

Two strains T. 141 and J. 192 were planted on 7 different dates at 10 days interval, the first and the last date of planting being 28th July and 26th September respectively. The results of the experiment indicate that July planting gave the highest yield in both the strains. The subsequent four plantings, *i.e.*, 7th, 17th and 27th August, and 6th September gave more or less similar yield but was lower than the July planting by about 6 per cent in the case of Jhelly and 14 per cent in the case of T. 141. The last two plantings, *i.e.*, 16th and 26th September gave very poor yield, being less than half in the case of J. 192 and one-fourth in the case of T. 141 as compared with July planting. It would, therefore, appear that these strains are suitable for late planting only upto 6th September. The particulars of the experiment are given in Statement 2.

VI. *The efficiency of (1) dibbling and (2) broadcasting in puddle*

In this experiment sprouted seeds of T. 141 were sown broadcast and dibbled in a well puddled field. The results indicate that there was no difference in yield between the two treatments. The particulars of the experiment are given in Statement 3.

VII. *N.P.K. Trial*

A parallel experiment as conducted in the Villagers' field in the Intensive Cultivation Centre was laid in the farm using the Strain T. 141 with six treatments, *viz.*,

1. Nitrogen:	(N_1) 30 lbs. in the shape of Ammonium sulphate nitrate in 2 doses
2. N_1. P_1. :	30 lbs. N+30 lbs. P_2O_5 as Superphosphate
3. N_1. P_1. K_1.	30 N ; 30 P_2O_5+30 K_2O as muriate of potash
4. N_2. P_2. :	45 N+60 P_2O_5
5. N_2. P_2. K_2.	45 N+60 P_2O_5+60 K_2O
6. Control:	No manure.

The results of the experiment indicate that the treatment N_2 P_2, N_2 P_2 K_2 gave the highest yield followed by the treatments N_1, N_1 P_1 K_1 and N_1 P_1. The treatment N_2 P_2 gave an increased yield of about 28 per cent over the treatment "no manure" control. The yield data are given in Statement 4.

The above experiment was also conducted in the second crop season with the strain MTU. 15. The results of the trial indicate that the treatment N_2P_2 gave the highest yield as in Kharif season followed by the treatments $N_2P_2K_2$, $N_1P_1K_1$, N_1P_1, N_1 and it gave an increased yield of about 42 per cent over "no manure" control.

From the yield data of first and second crop season it would be seen that a higher yield response to a tune of 14 per cent as compared to the response obtained in first season is obtained in the second crop season with the fertilizers.

VIII. *The effect of age of seedlings on yield of second crop*

It has been observed the time of planting and/or age of seedling has a great bearing on the flowering of the second crop of MTU.15 or G.E.B. 24. The second crop should complete flowering by the fourth, preferably third week of March, as otherwise the yield would be considerably affected for want of water at the maturing phase (the canal being closed on 15th April). To obviate the above difficulty, seedlings from November sown nursery were planted in the middle of January (earlier planting not feasible) as this crop flowered in the third week of March and matured by the third week of April. If, however, seedlings from December sown are planted in the middle of January, the crop flowers in the first week of April and the yield is considerably affected because it could not be given irrigation during its maturing phase (canal being closed on 15th April).

An experiment was laid to assess the loss in yield, if any, due to the different ages of seedlings in the case of the strain MTU. 15. Three treatments, namely, seedlings of (1)45, (2)51 and (3)61 day old were planted on 15th January in randomised blocks with 6 replications, adopting a spacing of 10″×3″ with 2 seedlings per hill. The results of the trial indicated that the treatment, *i.e.*, 51 days old seedlings was as good as the treatment, *i.e.*, 45 days old seedlings, while the treatment, *i.e.*, 61 days old seedlings gave 10 per cent reduction in the yield as compared with the treatment, *i.e.*, 45 days old seedlings. It may be mentioned here that the crop of the treatments 1, 2 & 3 completed flowering by the 28th March, 3rd April and 8th April respectively. Fortunately there was supply of water in the canal till the 3rd week of April as otherwise the late flowered crop of the treatment No. 1, *i.e.*, 45 days old seedlings would have been adversely affected and its yield reduced very considerably. It would, therefore, be necessary from practical considerations that seedlings are raised in the case of MTU. 15, in the third week of November and plant them in the middle of January for satisfactory yields. The particulars of the experiment are given in Statement 5.

IX. *Studies on seed rate*

A study on seed rate involving 6 treatments, *i.e.*, singles, 5, 9, 13, 17 and 21 seeds per hill (row to row one foot and six inches in row) was critically made with three strains T. 141, T. 1242 and G.E.B. 24. It would appear from the results that the treatment namely—single and five seeds per hill is the best under conditions obtainable here.

X. *Intensive Cultivation Centre*

1. Thirty-six maunds of high yielding paddy strains giving 10 to 15 per cent more yield than the farmers' varieties were distributed.

2. Demonstrating the advantages of sowing paddy mixed with dhaincha, the crop of the latter being buried as green manure to the rice crop at the time of *beaushenning.*

3. Popularising the growing of dhaincha plants for seed purposes along the field bunds at the time of beaushenning and at the time of planting.

4. Educating the farmers regarding the need for the maintenance of purity of nucleus seed and actually demonstrating to them in the fields the method of "roguing" the off types at the flowering and ripening periods.

5. Sixty-four simple manurial trials with nitrogenous, phosphatic and Potassic fertilizers were conducted with a view to demonstrating to the farmers the advantages of using fertilizers to rice crop. An increase in yield of about 200 lb. of grain over the control plot was obtained in many trials.

6. The improved strains of Jhelly. 192, BAM. 9 and T. 141 grown in observation plots scattered in the village Tarpur for the first time impressed the cultivators by their high yielding performances.

STATEMENT 1

Trial with Sowing practices

Object : To assess the merit of the different sowing practices.

Layout : Split plot with variety as main plot and methods as sub-plot treatments.

No. of replications : 8.

Plot size : Gross 30′×20′, Nett 29′×19′ (leaving one foot border all round).

Spacing : 12″×5′.

Seed rate : 40 lb. seed rate for dibble sown in puddle.

Varieties : T. 141 and T. 1242.

Treatments :

1. Transplanting on 27th July, 1956.
2. Transplanting on 27th August, 1956.
3. Dibble sown in puddle on 27th July, 1956.

Yield in lb. per acre

Treatment.	T_1	T_2	T_3	Mean.
1. Variety T. 141.	2195 (102·5)	2141 (100·05)	2140 (100·0)	2158·7
2. Variety T. 1242	2276 (134·4)	1479 (87·1)	1698 (100·0)	1817·7
Mean.	2235·6	1810	1919	

STATEMENT 2.

Object : To determine the optimum time of planting of T. 141 and J. 192.

Layout : Randomised block with 6 replications.

Plot size : 20′-0″×3′-9″.

Spacing : 9″×6″ in doubles per hill (Not one line all round harvested).

Treatments :

1. Planting on 28th July, 1956.
2. Planting on 7th August, 1956.
3. Planting on 17th August, 1956.
4. Planting on 27th August, 1956.
5. Planting on 6th September, 1956.
6. Planting on 16th September, 1956.
7. Planting on 26th September, 1956.
8. Planting on 28th July, 1956.
9. Planting on 7th August, 1956.
10. Planting on 17th August, 1956.
11. Planting on 27th August, 1956.
12. Planting on 6th September, 1956.
13. Planting on 16th September, 1956.
14. Planting on 26th September, 1956.

Yield in lb. per acre.

T. 141.			J. 192.		
	Treatments			Treatments	
1.	2594	100·0 (control)	8.	2346	100·0 (control)
2.	2152	82·93	9.	2102	89·5
3.	2276	87·74	10.	2218	94·5
4.	2249	86·7	11.	2086	88·9
5.	2176	83·88	12.	2125	90·5
6.	1668	64·3	13.	1637	69·7
7.	721	27·79	14.	1163	49·5

STATEMENT 3

Object : To assess the merits of sowing sprouted seed in puddle under (1) Broadcast (2) Dibbling.

Layout : Paired plot in AB BA Fashion with 12 replications.

Plot size : 99′×15′ (3·41 cents).

Seed rate : 60 lb. per acre.

Spacing : For dibble sown 12″×6″ with 6 to 8 seeds per hill.

Yield in lbs. per acre.

Broadcast.	Dibble sown.
1813·8	1818·2

STATEMENT 4

Object : To assess the efficiency of the N, P and K fertilizers in crop production.

Layout : Randomised blocks—6 replications.

Plot size : 99′×10′ (2·27 cents).

Spacing : 12″×6″ in doubles.

Variety : T. 141.

STATEMENT 4—*contd.*

Treatments :

T_1 : Ammonium sulphate Nitrate to supply 30 lb. N. per acre.

T_2 : Ammonium sulphate Nitrate to supply 30 lb. N. and Super phosphate to supply 30 lb. P_2O_5.

T_3 : T_1+T_2+Muriate of potash to supply 30 lb. of K_2O.

T_4 : Ammonium sulphate Nitrate to supply 45 lb. N.+Super phosphate to supply 60 lb. P_2O_5.

T_5 : T_4+Muriate of Potash to supply 60 lb. K_2O.

T_6 : Control—No manure.

N.B.—Super phosphate and Muriate of Potash applied in full as basal dose and Ammonium Sulphate nitrate in two equal doses *i.e.* 8th September and 22nd October, 1958.

Yield in lbs.

	T_1	T_2	T_3	T_4	T_5	T_6 (Control).
Acre yield :	2210	2100	2164	2331	2237	1891
	121·5	115·4	118·0	128·0	123·0	100·0

STATEMENT 5

Object : To assess the relative merits of the different ages of seedlings of MTU. 15 in the Second crop season.

Layout : Randomised blocks—6 replications.

Plot size : 66′×15′-10″ (*N.B.*—One line all round harvested).

(Nett plot size : 65′-6″×14′-2″=2·124 cents).

Spacing : 10″×3″ seedlings in doubles per hill.

Treatments :

T_1 : Seedlings 61 days old (Seed bed sown on 16-11-56).

T_2 : Seedlings 51 days old (Seed bed sown on 26-11-56).

T_3 : Seedlings 45 days old (Seed bed sown on 2-12-56).

Yield in lb.

	T_1	T_2	T_3
Acre yield :	1970	2228	2185
	90·2	101·9	100·0

PROGRAMME OF WORK FOR 1957-58.

AGRONOMY DIVISION

1. Study of yield performance of different duration varieties.
2. Trial of varieties suitable for late *aman* planting and for double cropping.
3. To determine the suitability of various crops for growing in rotation with rice.
4. Study of the relative efficiency of various nitrogenous fertilizers.
5. Determination of the optimum dose, time and method of application of different nitrogenous fertilizers and their residual and cumulative effect on the soil fertility.
6. Study of the residual effect, of organics and inorganic fertilizers.
7. Study of the efficiency of various herbicides for control of weeds in the rice fields and to determine the optimum dosage and time of their application.
8. To study the suitability of various green manure crop for rice and to determine their optimum time of sowing and incorporation in the soil.

BOTANY DIVISION.

1. Maintenance and study of genetic stocks including the F.A.O. World Catalogue.
2. Maintenance of nucleus seed of primary strains.
3. Improving yield by :—(i) Introduction—Preliminary trial of Genetic Stocks. (ii) Secondary selection in Chinese varieties for evolution of high yielding strains and (iii) Hybridization—
   a. between *japonica* and *indica* rices.
   b. Within *indica* group of rices for high yield and early maturity.
4. Breeding for upland condition.
5. Breeding for disease resistance.
6. Breeding for high yielding Basmati strains.
7. Breeding for non-lodging habit.
8. Study of cultural practices in relation to lodging.
9. Estimation of loss due to lodging at various stages of plant growth.
10. Breeding for better quality and high yielding strains.
11. Genetics—
   (*a*) Study of the inheritance of hairiness, cluster habit, bunched panicle, beaked lemma and palea and dwarf habit.
   (*b*) Study of inter-relationship of genes for anthocyanin pigment and
   (*c*) Relationship between dwarf habit and panicle size.
12. Cytology—Cytological research is on three topics—
   (*a*) Normal and variant cytology of cultivated rice.
   (*b*) Evolution and inter-relationships in the genus Oryza.
   (*c*) Origin of cultivated rice from wild species and differentiation into sub-species.

Under (*a*) the current year's work is on developing suitable techniques for study of pollen mitosis and also to isolate and characterise aneuploid rice cultures. Under (*b*) the relationships of species O. alta and O. latifolia are to be followed in detail. Under (*c*) the work started in previous year is to be continued and semi-sterile hybrids are to be used for tracing the cytological differences between wild and cultivated rices and between sub-species of rice.

CHEMISTRY DIVISION

1. Investigations on nutrient availability in water logged soil state and its relation to plant growth.
   (*a*) Availability of nitrogen with different fertilizers with respect to time and method of application.
   (*b*) Study of ammonifying capacity of soil nitrogen and its relation to soil fertility and nitrogen requirements.
2. Investigations on nutrient assimilation by rice plant.
   (*a*) Comparison of ammoniacal and nitrate fertilizer as nitrogen carrier of rice.
   (*b*) Reaction of different varieties to increasing levels of nitrogen supply.
   (*c*) Influence of soil type on growth, development and nutrient assimilation by rice plant.
   (*d*) Growth and nutrient assimilation studies under graded nitrogen levels with and without phosphate and potash application.

ENTOMOLOGY DIVISION

1. Study of reactions of Genetic Stocks to pests in general and leaf hoppers, gall fly and stem borers in particular (Sarad and Dalua varieties).
2. Studies on insect resistance in rice with special reference to gall fly and stem borers.
3. Efficacy of different methods of application of insecticides in the control of rice pests.
4. Effect of gall fly and stem borer incidence on tillering and yield.
5. Estimation of loss in yield due to gall fly and stem borers.
6. Insecticidal trials to control pests of rice.
7. Incidence of pests in relation to manuring.
8. Studies on seasonal abundance of pests with a view to forecasting outbreaks of major pests.
9. Studies on alternate hosts of major pests of rice.
10. Collection of indigenous parasites of the more important pests of rice with a view to utilizing them for biological control of pests of rice.
11. Studies on gall formation in rice.

MYCOLOGY DIVISION.

1. Study and estimation of resistance to diseases in field of the collection of types under genetic stocks.
2. *Helminthosporium disease*.
   (*a*) Co-ordinated trial of selected resistant varieties in different States in India.
   (*b*) Artificial infection tests on early types in genetic stocks for selection of resistant types.
   (*c*) Breeding resistant types.
   (*d*) Study on the nature of disease resistance of rice varieties.
3. *Blast disease*.
   (*a*) Co-ordinated trial of selected resistant varieties in different states in India.
   (*b*) International Co-operative trial on breeding for blast resistance.
   (*c*) Artificial infection tests on early types in genetic stocks for selection of resistant types.
   (*d*) Breeding resistance varieties.
   (*e*) Study on the nature of disease resistance of rice varieties.
   (*f*) Control of blast spraying and dusting.
   (*g*) Study on the nature of injury to rice plant due to spraying copper fungicides.
   (*h*) Estimation of loss in yield due to blast.

STATISTICS DIVISION

1. Correlation and development studies of plant characters.
2. Sampling of grain measurements and weight.
3. Study of fertilizers response surfaces.
4. Application of discriminant function for selection in segregating progenies.

FARM DIVISION.

1. Multiplication of improved strains.
2. Determining the merits of sowing practices namely, (i) dibbling ; (ii) broadcast sowing of sprouted seeds in puddle and (iii) transplanting under optimum conditions.
3. Maximisation of crop yield under the improved methods of cultivation.
4. Enlargement of the extension work in the Intensive Cultivation Centre.

PUBLICATIONS.

Ghose, R. L. M.	Rice Research—These forty-five years. Indian Farming, 1956.
Ghose, R. L. M.	Rice experiment stations in India. I. R. C. News Letter No. 19, September, 1956.
Ghose, R. L. M.	Linkage studies in rice and jute. Indian J. Genet. and Pl. Breed. **17**: 329-335.
Ghose, R. L. M., Ghatge, M. B., and Subrahmanyam, V.	Rice in India, 1956. I. C. A. R. Monograph.
Israel, P.	Insect pests of rice in India and their control. I. R. C. News Letter No. 19, September, 1956.
Padmanabhan, S. Y.	Rice diseases in India. I. R. C. News Letter No. 19, September, 1956.
Padmanabhan, S. Y.	Relation between the loss in viability and some seed borne microflora in rice. Proceedings Ind. Acad. Sci. 1957. XLIV. Sect. B.
Padmanabhan, S. Y. and Israel, P.	Prospects bright for pest and disease control. Indian Fmg. 1956. **6**: 34-39.
Sampath, S.	A study of wild rices. Indian Science Congress, 1957. 44th Session. Part III, Abst. 86.
Vachhani, M. V., and Abichandani, C. T.	Fertilizer use in rice production in India. I.R.C. News Letter, **19**: 1 March 1956.

TRAINING

Six Post-Graduate students in the second year of Associateship course worked on their research problems at this Institute during this period. They subsequently submitted their thesis based on the research work done at this Institute and qualified for the diploma of Associateship of Indian Agricultural Research Institute. The subjects on which they did research work were the following :—

A. *Rice Botany*

(1) Genetical and cytological studies of sterility in interracial hybrids of rice.

(2) Studies of hybrids of *japnica & indica* rices under normal and high levels of soil fertility.

(3) Genetics of *Oryza sativa*. Inheritance of anthocyanin pigmentation and other morphological characters in intervarietal crosses within the *indica* group.

(4) Cytogenetical studies in the genus *Oryza*.

B. *Rice Agronomy*

(5) Effect of placement and split application of different nitrogenous fertilizers on yield and other agronomic characters of rice.

(6) Effect of time of planting on the performance of some *Boro* (Spring) varieties of rice.

STAFF

Director :	R. L. M. Ghose, M.Sc., F.A.Sc.

AGRONOMY DIVISION

Agronomist :	Moti V. Vachhani, B.Ag., Ph.D.
Research Assistant :	M. S. Chaudhury, B.Sc., Assoc. I.A.R.I.
Research Assistant :	M. V. Rao, B.Sc. (Ag.).

BOTANY DIVISION

Geneticist & Botanist :	R. L. M. Ghose, M.Sc., F.A.Sc.
Assistant Botanist :	W. T. Butany, B.Sc. (Agri.) Hons., Assoc. I.A.R.I., M.S (Texas).
Research Assistant :	R. K. Mishra, M.Sc.
Research Assistant	R. Seetharaman, M. Sc.
Research Assistant :	K. S. Murthy, M.Sc.
Research Assistant :	C. Gangadharan, M.Sc.

CHEMISTRY DIVISION

Agricultural Chemist :	C. T. Abichandani, M.Sc., Ph.D., A.R.I.C.
Research Assistant :	S. N. Patnaik, M.Sc.
Research Assistant :	R. R. Dutta, M.Sc.

ENTOMOLOGY DIVISION

Entomologist :	P. Israel, M.A., F.R.E.S.
Research Assistant :	G. Vedamoorthy, B.Sc. (Hons)., M.A., Assoc. I.A.R.I.
Research Assistant :	Y. S. Rao. M.Sc.

MYCOLOGY DIVISION

Mycologist :	S. Y. Padmanabhan, B.Sc. (Hons.)., M.A., Assoc. I.A.R.I.
Assistant Mycologist :	Durgadas Ganguly, M.A., Ph.D.
Research Assistant :	G. H. Chandwani, B.Sc. (Ag.).
Research Assistant :	P. D. Das, M.Sc.

FARM DIVISION

Farm Superintendent :	M. Subbiah Pillai, B.A., B.Sc. (Agri.).
Research Assistant :	C. N. Relwani, B.Sc. (Agri).

STATISTICS DIVISION

Statistician :	M. P. Jha, M.Sc.

CYTOLOGY DIVISION

Cytologist :	S. Sampath, M.A.
Research Assistant :	D. V. Seshu, M.Sc.

2ND FIVE-YEAR PLAN—SCHEME NO.1.

Cooperation of Rice Research between Central Rice Research Institute and different Rice growing States.

Research Assistant (Class II Non-Gazetted)	N. A. Parasuram, B.Sc. (Agri.).
Research Assistant (Class III) :	N. K. Chyau Patnaik, M.Sc.
Research Assistant (Class III) :	M. V. S. Sastry, M.Sc.
Research Assistant (Class III) :	J. Veera Raghavan, M.Sc.

I.C.A.R. Scheme for further research on Green Manuring Crops for paddy

Research Assistant :	P. Narasimha Rao, M.Sc.

I.C.A.R. Scheme for Survey and Collection of Breeding Materials from Jeypore tract of Orissa State.

Assistant Botanist :	S. Govindaswamy, M.Sc., Ph.D.

I.C.A.R. Scheme for Breeding paddy strains resistant to lodging

Research Assistant :	M. J. Balakrishna Rao, M.Sc.
Research Assistant :	T. E. Srinivasan, M.Sc.

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